Technical Report 1078

Functional Capabilities of Four Virtual Individual Combatant (VIC) Simulator Technologies: An Independent Assessment

Robert J. Pleban, Jean L. Dyer, and Margaret S. Salter
U.S. Army Research Institute

Jamye B. Brown
Auburn University
Consortium Research Fellows Program

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EDGAR M. JOHNSON
Director

Technical Review by

Eugene Dutoit, DBBL
Bruce W. Knerr, ARI

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14. ABSTRACT *(Maximum 200 words)*:

This research describes the results of an independent assessment of the functional capabilities of four virtual individual combatant (VIC) simulators. Infantry soldiers were given the opportunity to operate each VIC in a series of squad-based scenarios requiring the performance of both individual and collective tasks in a desert or urban setting. The results indicated that the more realistic the action or equipment used and the more reliable the VIC, the more the soldiers liked that system. An important consideration in the development of future generation VICs is the specific purpose (s) to be served by these systems, e.g., mission planning and rehearsal versus training individual soldier skills. The data collected from this research provide an important first step in the development of a set of dismounted infantry requirements for manned simulators that will support the integration of the individual soldier into the virtual battlefield.

15. SUBJECT TERMS

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Robert J. Pleban, Jean L. Dyer, and Margaret S. Salter
U.S. Army Research Institute

Jamye B. Brown
Auburn University
Consortium Research Fellows Program

Infantry Forces Research Unit
Scott E. Graham, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

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FOREWORD

This report describes the results of an independent assessment of the functional capabilities of four virtual individual combatant (VIC) simulator technologies conducted by the Army Research Institute's (ARI) Infantry Forces Research Unit (IFRU) under the Work Package "Light Infantry Training Environments". The assessment was part of a cooperative research agreement between ARI-IFRU, the ARI Simulation Systems Research Unit, and Lockheed Martin Corporation in support of the Dismounted Warrior Network project. The assessment took place during the DWN User Exercises which were conducted at the Dismounted Battlespace Battle Lab (DBBL) at Fort Benning, Georgia. The User Exercises were part of a multi-phase research project aimed at generating a validated Dismounted Infantry simulation requirements document.

This research was conducted to provide the infantry community with the opportunity to exercise and evaluate four technologically diverse individual simulators in various mission oriented contexts. The primary focus of this research was to identify the strengths and weaknesses of the four VICs from the user perspective. The findings from this research have been provided to the DBBL and to the Simulation, Training, and Instrumentation Command. They provide an important first step in guiding the development of future generation VICs and VIC system requirements in general.

ZITA M. SIMUTIS
Technical Director

FUNCTIONAL CAPABILITIES OF FOUR VIRTUAL INDIVIDUAL COMBATANT (VIC) SIMULATOR TECHNOLOGIES: AN INDEPENDENT ASSESSMENT

EXECUTIVE SUMMARY

Research Requirements:

One of the objectives of the Dismounted Warrior Network (DWN) project is to investigate and identify critical dismounted infantry simulation requirements and capabilities through a series of engineering experiments and user exercises. As part of a cooperative research project, the Army Research Institute's (ARI) Infantry Forces Research Unit (IFRU) conducted an independent assessment of the functional capabilities of four prototype virtual individual combatant (VIC) simulator technologies. The assessment took place during the DWN User Exercises which were conducted at the Dismounted Battlespace Battle Lab (DBBL), at Fort Benning, Georgia. The focus of the User Exercises was to identify the strengths and weaknesses of the VICs from the perspective of the infantry soldier and to use these findings, in conjunction with engineering data collected earlier, to guide the development of future generation VICs and simulator systems requirements in general.

Procedure:

Eight soldiers from Fort Benning, Georgia participated in the virtual reality research. Soldiers received approximately one week of training in which they were briefed on the major characteristics and functional aspects of each VIC simulator. They were then given the opportunity to operate each VIC in a series of scenarios based on an infantry squad performing selected individual and collective tasks in either a desert or urban setting. The actual User Exercises lasted for two weeks. Paper-and-pencil questionnaires designed to assess the functional capabilities of the VICs across various dimensions were administered at selected times throughout the exercises. A structured interview was conducted with the soldiers at the end of the User Exercises.

Findings:

All VICs had certain strengths and weaknesses in their approaches. A key factor in considering the development of future generation of VICs is the level of realism provided by the system. The more realistic the action (e.g., using a treadmill to actually walk versus using a joystick) or equipment (actual demilitarized weapon versus mockup), the more the soldiers liked the system. System reliability was another important theme which affected how well a particular VIC system was received by the soldiers.

Utilization of Findings:

The data collected from this research will provide an important first step in the development of a set of dismounted infantry requirements for manned simulators which will support the integration of the individual soldier into the virtual battlefield.

FUNCTIONAL CAPABILITIES OF FOUR VIRTUAL INDIVIDUAL COMBATANT (VIC) SIMULATOR TECHNOLOGIES: AN INDEPENDENT ASSESSMENT

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Introduction

The Army has made a strong commitment to Distributed Interactive Simulation (DIS) as the major resource for conducting collective training and for planning and rehearsing military operations. The current DIS training system, Simulation Networking (SIMNET) and its successor, the Close Combat Tactical Trainer (CCTT), provide effective training for soldiers fighting from vehicles, but not for individual dismounted soldiers.

The introduction of the individual into the virtual battlefield had to be deferred because the number and complexity of models required to represent even a modest force of individual combatants exceeded the capacity of affordable real-time computing resources. However, rapid progress in the area of virtual environment systems has brought new technology to bear in addressing the complex issues of individual combat simulation. These systems immerse individual participants into synthesized surroundings through their own direct sensory experience. The resulting experience is one of personal presence and direct control of behaviors in the virtual world, rather than controlling tools or equipment which, acting as mediators, translate the individual's actions into observable effects in the virtual environment (Jacobs et al., 1994).

If this new technology is successful it provides for the possibility for expanding the capabilities of distributive interactive simulation to support mission proficiency training, mission planning, and mission rehearsal for the individual. This is important since the Army has assigned prime roles to airborne, airmobile, and light infantry divisions, and to Special Operations Forces (SOF), whose combatants fight primarily on foot (Jacobs et al., 1994).

In April 1997, the Army Research Institute (ARI) Infantry Forces Research Unit (IFRU) agreed to participate in a cooperative research project with the ARI Simulator Systems Research Unit and Lockheed Martin Corporation. The lead organization in this activity was the Army's Simulation, Training, and Instrumentation Command (STRICOM). The primary role of the IFRU in this project was to provide an independent assessment of the functional capabilities of four prototype virtual individual combatant (VIC) simulator technologies. The assessment took place during the Dismounted Warrior Network (DWN) User Exercises that were conducted over a three-week period at the Dismounted Battlespace Battle Lab (DBBL) at Fort Benning, Georgia. The User Exercises were only one part of the multi-phase DWN project which was first articulated by STRICOM in the Individual Combatant Simulation Technology Plan in November 1995 (Jones, 1995). The primary focus of the project was on the generation of a simulation task analysis for Dismounted Infantry (DI) components.

Several factors affected the assessment, and the conclusions and recommendations that could be made. First, the VICs were prototypes with different technologies used for each. These technologies were not fully developed and were undergoing modifications and enhancements as the exercises were executed. Some VICs were developed as a proof of principle concept for a particular capability, for example, as an untethered approach to integrating the dismounted

soldier in a virtual world or as a system to simulate selected capabilities of the Army's Land Warrior system. Second, in contrast to a final system where all VICs would be the same technology, the exercises integrated four different technologies. Although this created some discrepancies to which soldiers had to adjust, it did allow a direct comparison of the impact of different technological solutions to simulating the same functions, e.g., different combinations of technologies for simulating movement in the virtual world. Third, the exercises were conducted at the fire team level. Except for the team leaders, the soldiers had limited field experience. The focus was, of necessity, on fire team and individual soldier tasks and the execution of those tasks. Therefore, the exercises did not directly address the adequacy of the VICs in other domains such as leader decision-making processes, mission rehearsal, or training research and development. Fourth, the scenarios involved a squad, with the second fire team depicted by computer-generated, semi-automated forces (SAF). As there was limited interaction between the two fire teams (the VIC fire team and the SAF fire team), no conclusions could be drawn regarding the effectiveness with which these two technologies were integrated.

DWN Background

The objectives of the DWN project were to develop requirements for DI simulation, specifically to investigate requirements for manned simulators (i.e., VICs), to support the integration of the individual soldier into the virtual battlefield; to integrate existing DIS compatible DI simulation systems; and to evaluate DI technologies and systems. To address these objectives, Lockheed Martin designed a set of engineering experiments along with a series of user exercises (See Lockheed Martin, 1997 for a detailed description and analysis of the engineering experiments). These exercises were an adjunct to the task analysis effort. The purpose of the exercises was primarily a virtual simulation technology demonstration/proof of concept.

The time and resources required to systematically research and identify the technology issues associated with providing soldier capabilities in the virtual world, and then develop the specific simulators to allow a complete comparison of these issues was viewed as too costly. Instead, it was decided to survey existing solutions to these problems and select from these a subset of VICs to use in the DWN exercises. These VICs represented a range of solutions to specific issues of interest (i.e., move, shoot, communicate, orient, recognize).

VIC Descriptions

Four VIC technologies were used in the DWN exercises. With three of the four, soldiers, to varying degrees, reacted physically as they would do in the real world. The extent and type of real-world behavior that was possible discriminated these three VICs, which were labeled VIC Alpha (A), Bravo (B), and Foxtrot (F). In turn, these three VICs used different technologies to "reproduce" soldier actions in the virtual environment (VE). With the fourth VIC, VIC Charlie (C), the intent was only to depict soldiers' real world actions in the VE. The soldier in VIC C manipulated computer controls, and therefore did not respond with physical actions that approximated real-world actions.

Descriptions of each VIC follow. These descriptions provide functional, not technical, information on each system. For each VIC, a general description of its distinguishing features is presented first, followed by information on movement and body positions, shooting, seeing, and audio and soldier communication. In addition, comments are made on special features of each VIC and capabilities not utilized in the DWN exercises. VICs A, B, and F are described first; VIC C, last.

There were some common VIC features. One feature related to determining kills made by the VIC soldiers and the semi-automated forces (SAF). The rules of engagement for the exercises dictated VIC kills according to distributed interactive simulation (DIS) standards where when a soldier was hit, he was killed. VIC C, however, played a stochastic, rather than a deterministic probability of hitting, in accordance with the JANUS wargame algorithms. Another common feature was that communication among the VICs was via wireless radio net. Head sets and mouth mikes (or microphone) were used by all VIC soldiers. All systems used three-dimensional, color, computer graphics to display the VE. The VE consisted of two separate data bases: Desert (29 Palms) and MOUT–urban terrain (from the Fort Benning MOUT site). All soldiers had unlimited ammunition, although some of the VICs could restrict the rounds available.

In order to have all VICs interface with each other, only those functions common to all VICs and compatible with the DIS protocols were implemented. In other words, the lowest common denominator capabilities were played. For example, although hand and arm signals were capable in some VICs, they were not depicted, as these were not possible with all VICs. Each VIC had some features that were not put in use; in some exercises, soldiers used features unique to a VIC.

At the start of the exercises, every VIC soldier had the same graphical representation in the VE; they were identical quadruplets. There was no way, for example, to discriminate the VIC A soldier from the VIC C soldier, nor any way to discriminate the fire team leader from fire team members. To solve this problem, artificial labels (A, B, C, or F) were generated for each VIC and used throughout the exercises.

VIC A

Primary features. The distinguishing features of VIC A were that the soldier was not tethered to any external mechanism; body sensors allowed his position to be articulated over the DIS. The soldier viewed the VE through a wireless helmet-mounted display (HMD). An optical tracking system captured data on body position which, in turn, was converted into DIS protocol data units which were transmitted over the DIS network (See Figure 1).

There were 19 sensors attached to the soldier in the tracking system used in VIC A. Sixteen were attached to the soldier (boots, knee, arm, head, and back); three were on the rifle.

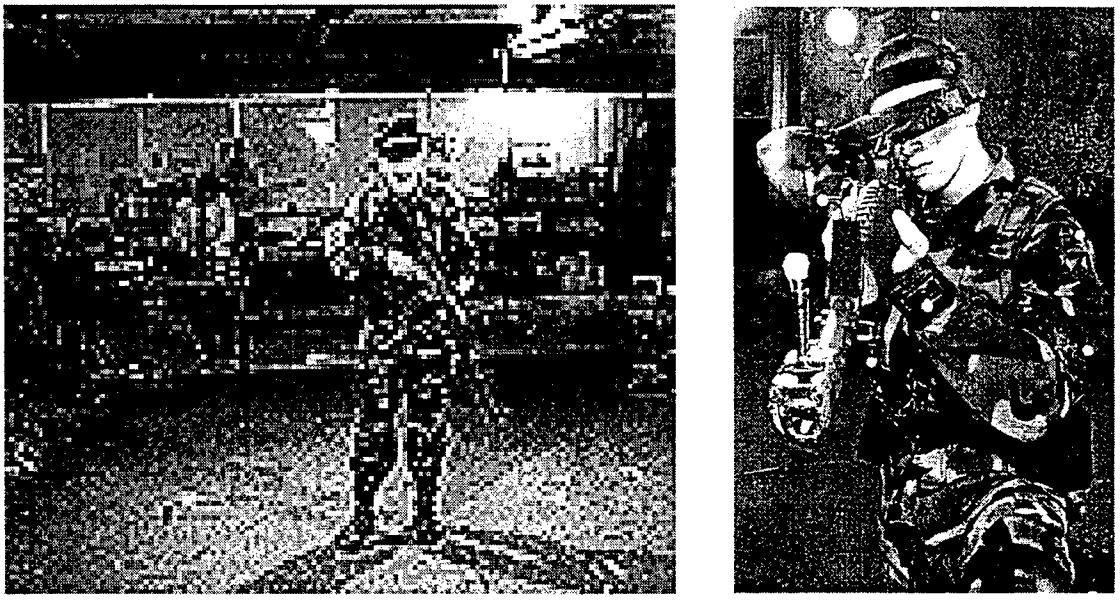

Figure 1. VIC A.

Movement and body position. Although the soldier was not tethered in VIC A, not all body positions were possible. In the prone position the soldier risked damaging some sensors. Furthermore, the limited range of the optical tracking system prevented accurate determination of body position when the soldier assumed the prone position. The soldier could kneel, however. In this position, the software portrayed the VIC A soldier in the VE as being prone. In the very first exercises, however, the software portrayed the VIC A soldier as being close to the ground when he was really kneeling. While standing in the circle, the VIC A soldier was portrayed over the DWN as running. While kneeling in the circle, he was portrayed as crawling.

The soldier's movements were also constrained. In addition, movement was unlike that in the real world. In general, to move in the VE of VIC A, the soldier had to stop in the real world. To stop in the VE, the soldier had to move in the real world. In VIC A the soldier could walk freely within an 8 x 8 ft area which corresponded to an 8 x 8 ft area in the VE. In the middle of this box was an 18 inch diameter circle. To travel any distance beyond that in the 8 x 8 ft box, the soldier had to step in this circle. When the soldier was in this circle, he moved automatically in the VE, but he could not control his speed of movement. The system automatically increased his movement to the maximum speed, 3.6 m/s, allowed in the exercises. The soldier could temporarily stop moving while staying inside the circle, by moving his waist more than 15 degrees. Or he could stop movement completely by stepping outside the circle and not walking. In order to go backwards, the soldier had to turn around. Direction of movement corresponded to the direction of the soldier's waist. The cardinal directions (north, south, east, and west) were marked on the floor. In the urban environment, when VIC A bumped into a wall, the soldier saw stars in his HMD.

Shooting. To fire, the soldier shouldered and aimed his weapon as he would in reality. A mockup of an M16 rifle was used. As the soldier had to use the HMD for all visual input, a representation of the rifle's iron sights was projected through the display. There were no wires attached to the rifle. VIC A used a single-round burst when simulating the M16, and an 8- or 10-round burst for the SAW (Squad Automatic Weapon). Firing was done from a standing unsupported or a kneeling position. When in the kneeling position, however, the VE soldier was considered prone with a sight picture 2 feet from the ground. Firing the weapon was better when the soldier was outside the circle, as the virtual movement when in the circle made it hard to hold the weapon steady and to achieve a constant aiming point.

Although the VIC A soldier was killed when hit, the system can play probabilistic kills if needed. The soldier knew he had been killed when the HMD view stopped and he saw the sky in the desert or the ceiling of a room in the urban data base. The system did not and could not restrict the amount of ammunition available.

Seeing. The HMD had a 45 degree horizontal and 33 degree vertical field of view, and a 360 degree field of regard in three dimensions. The soldier could scan in a direction that was different from the one in which he was moving. Resolution of the HMD display was 420 x 230.

Audio and soldier communication. The VIC A soldier heard battlefield sounds via three-dimensional (distance, speed, and direction) audio system, with speakers in each corner of the 8 x 8 foot box. He also had a head set for soldier-to-soldier communication.

Other background information. VIC A can be configured with up to 68 sensors to provide more articulation of the soldier, including hand and arm signals. It also has other forms of movement. The soldier can become fatigued by walking in place in the circle. When using a larger, 30 in. circle, the further the soldier goes from the center, the faster he moves. Backward movement is also possible in this configuration. The box can also be larger, up to 14 ft square, allowing natural movement within a larger area.

VIC B

Primary features. The distinguishing features of VIC B were the real-time movement and forces associated with this movement generated by an omni-directional treadmill (ODT); the integrated helmet assembly subsystem (IHAS) which gave the soldier indirect fire capability with his rifle; and the four rear-view projection screens that provided the soldier a 360 degree wrap-around field of view of the VE. The ODT occupied an 8 x 8 ft space.

During exercises when the soldier used his unaided eye rather than the IHAS, the screen to his rear did not display the real world. Only three of the four screens were active. However, when using the IHAS, the soldier could view this rear screen by pointing his rifle in that direction. An electro-magnetic tracker was used to track the soldier's physical position as well as his rifle.

Figure 2. VIC B.

Movement and body positions. In the real world, the VIC B soldier could assume only the standing position. To assume different positions in the VE, the VIC B soldier used a button on the rifle, that cycled him from the standing to the kneeling to the prone position and back to the standing position. The scene the soldier viewed was adjusted automatically to his height above the ground in the VE.

With the ODT, the soldier was tethered to a waist and overhead harness system. This system served as a tracking device for displaying the body and weapon positions over the DIS and also as a safety device. The ODT allowed the soldier to walk in any direction, 360 degrees, by rotating his body while moving. The soldier controlled his movement pace. It was possible to run on the ODT, provided the soldier had acquired this skill. The VIC B soldier could not stop suddenly as he was likely to lose his balance. He had to stop in a manner similar to how an individual stops when walking on ice. The VIC B soldier could move forward, backward, and to either side. However, the preferred method of going backwards was to turn around.

To crawl in the VE, the soldier cycled to the prone position by using the "position" button on the rifle. Then as he walked on the ODT, he was displayed as crawling in the VE. When the position button on the rifle was in the kneeling position, however, the VIC B soldier could not move in the VE.

VIC B was designed to simulate the exertion created by moving at different paces and by moving on slopes. When the soldier accelerated, VIC B simulated the physical effort associated with this acceleration by having the soldier push against a force that was applied through the

harness system. Similarly, soldier movement was affected by the slope of the terrain, but not the terrain's texture (e.g., swamp, shrubs, sand). Forces were applied to both uphill and downhill movement. In the urban environment, however, no forces were applied by the system when the soldier went up and down the stairs.

In MOUT, the soldier stopped in the VE when he hit a wall. He could not go through walls. He could not move; he could only slide out backwards. To eliminate these problems, VIC B was modified during the exercises. A second button on the rifle was programmed to allow the soldier to move when stuck. Depending on the soldier's angle of impact with the wall, this feature moved the soldier ahead in the VE about one meter or moved him forward only slightly, thereby freeing him from the wall.

Shooting. The VIC B software assumed the rifle was shouldered. To shoot, the rifle had to be on the soldier's shoulder. If a soldier fired from the hip, he would, therefore, hit low. In the real world, the soldier in VIC B fired from a standing unsupported position only. To fire from another position, the soldier had to activate the position button on the rifle. He could then view the VE scene from the perspective of the kneeling or prone position.

The soldier used a mockup of the M16 rifle. It had cross-hairs for aiming. A circle in the center of the cross hairs turned blue when the rifle was aimed at a friend; red when aimed at the enemy. However, the soldier only saw the circle turn dark, providing no distinction between friend and foe. A filled-in circle did not guarantee a hit, as the target had to be in the center of the cross hairs as well.

The VIC B soldier could fire in one of two modes, with his unaided eye or with the IHAS. The IHAS on VIC B was developed to simulate or represent the indirect view, target acquisition capabilities of the Land Warrior system. In particular, Land Warrior will have a camera on the rifle, whose image will be projected on a monocular eyepiece attached to the soldier's helmet. This capability allows the soldier to fire the rifle accurately without shouldering it and without exposing himself, as is the case when using the rifle's iron sights. When using the IHAS, the soldier saw in the direction the rifle was pointed. The IHAS covered only one eye and could be used with either eye. The soldier had a 30 degrees field of view with the occluded eye and a 360 degree field of regard. The nonoccluded eye gave the soldier peripheral vision when using the IHAS. The IHAS capability allowed the soldier to shoot around corners or to shoot at targets to his rear. With no IHAS, the soldier used iron sights. Hitting was not as precise under these conditions, particularly if the soldier aimed away from the center of the target.

The M16A2 rifle was the only weapon system simulated by VIC B in the User Exercises, and currently is the only weapon capability simulated. VIC B had only one mode of firing - a three-round burst on the rifle. No ammunition restrictions were played.

The soldier was informed that he was killed through his headset. Words indicating he was killed were also displayed on the screen to his rear.

Seeing. As the soldier walked on the ODT, changing speed or direction, the computer-generated graphics were corrected to provide a consistent view of the VE. The four rear-projection screens on VIC B joined at a 90 degree angle. At these corners, there was some loss of the visual scene - about a four inch gap. Each screen was 8 ft horizontal x 6 ft vertical. The field of view through the eye using the IHAS was 30 degrees, with peripheral vision capability using the nonoccluded eye. By using the peripheral vision of the nonoccluded eye, the field of view with IHAS could be considered 270 degrees. The field of regard with both the IHAS and unaided was 360 degrees. Screen resolution was 640 x 480. The VIC B soldier could scan in a direction different from his movement.

Audio and soldier communication. Soldiers wore a head set to hear messages from and send messages to the other VICs. However, considerable noise was produced by the ODT when the soldier moved. Thus, VIC B soldiers typically stopped movement in order to communicate with the other VICs and to hear their messages. Battlefield sounds were broadcast over a three-dimensional (distance, speed, direction) audio system.

Other background information. Hand and arm signals were not possible with the calibration system, DI-Guy, used by VIC B.

VIC F

Primary features. The distinguishing features of VIC F were the foot pedal type device the soldier used for moving; the single rear-view projection screen to his front that displayed the VE; and the head-motion tracking system. The soldier could move via the foot pedal or walk freely within a 10 ft square area. Except for the foot pedal, the soldier was not tethered. The soldier's body position (standing, kneeling, prone), as depicted in the VE, was tracked by a magnetic-based sensor system on the soldier's head. VIC F was the only VIC that used a demilitarized weapon system, specifically a demilitarized M203, as opposed to the mock-up rifle in VICs A and B and a joystick in VIC C.

Movement and body positions. To assume a standing, kneeling, or prone position in the VE, the VIC F soldier assumed the same position in the real world.

There were two ways to move with VIC F: using the foot pedal or walking within the 10 ft square area in front of the screen. As more pressure was put on the foot pedal, the faster the movement, culminating in a run. When the soldier let up on the pedal he slowed, but the system did not allow him to come to a complete stop. The soldier had to get off the foot pedal to stop completely, and the scene to his front stopped about 5 seconds later. The soldier's head controlled his direction of movement when using the foot pedal or the 10 foot square space. When his head moved, the scene to his front changed, rotating with his head position.

To move backwards, the soldier put pressure on the foot pedal with the heel of his foot. When going backwards, the computer set the speed to be slower than forward movement. In general, speed of movement was programmable. To crawl in the VE, the soldier had to lie down on the floor and depress the foot pedal to control the crawl speed.

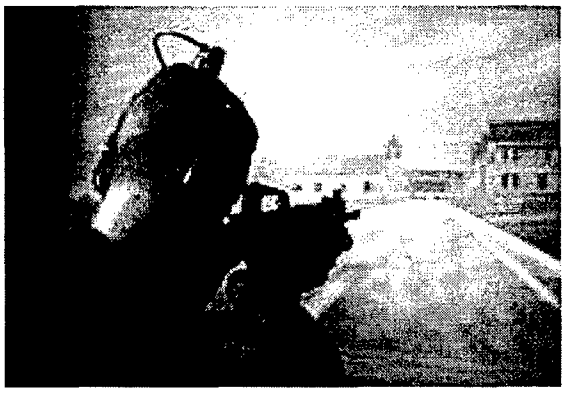

Figure 3. VIC F.

Shooting. To fire, the soldier shouldered and aimed the rifle using the iron sights as he would in the real world. The VIC F soldier could fire standing unsupported, kneeling, or prone within the 10 ft square area. However, when firing from the prone position, there was a tendency for the VIC F soldier to shoot himself. This problem arose from the acoustic sensors mounted above the soldier's head and on the weapon. The electronic transmissions between the sensors were disturbed by background noises, so that in the most extreme position (prone), it was impossible to aim the weapon accurately. Tracking accuracy was lost and therefore the soldier could shoot himself. (In a sound proof area, this problem did not occur.)

VIC F simulated the SAW as well as the M16A2 rifle. The trajectory of the weapon was used. Both a single-round burst and three-round burst were used for the M16. For the SAW, a one- to n-round burst was used with the maximum burst controlled by the soldier. Rounds that were fired were visually depicted in this system. Probability of hit and kill values could be configured as desired with system software, but were set in accordance with DIS standards for the user exercises. When hit, the VIC F soldier was also killed. The soldier was informed through his headset when he had been killed.

VIC F can be configured so the soldier runs out of ammo and must change magazines. However, these capabilities were not played.

The weapon must be calibrated initially. Basically, this calibration consists of finding the location of the soldier's eyeballs, so the system is adjusted to each soldier's height.

Seeing. The soldier's view was dependent upon his distance from the 8 x 10 ft screen. The closer to the screen, the wider the field of view, reaching about a maximum of 180 degrees

when close to the screen. This allowed the soldier to "peer" around corners, to "stick" his head out without exposing his entire body. The field of regard was 360 degrees. Screen resolution was 1280 x 1024.

When moving, the direction of movement corresponded to the movement of the soldier's head. Therefore, the VIC F soldier could not scan in a direction different from his movement. But when standing still, the VIC F soldier could scan as he would in the real world.

Audio and soldier communication. Soldier communication was through a stereo head set and mouth mike. Battlefield noises were directional, but limited because of background noises that interfered with VIC F's acoustic system.

Other background information. VIC F lacked sensors and therefore had no hand and arm signal capability. VIC F used the DI-Guy model that was also used in VIC B. Certain limitations imposed during the DWN User Exercises impacted on the features of VIC F that were employed. If four VIC F systems had been connected, then the soldier could have localized the direction and relative position of the fire team members. Labels would not have been required to identify fire team members. The direction of enemy fire could have been determined as VIC F's audio is head-tracked, letting the soldier use his head as he normally would to localize sounds. However, the intercom system in the User Exercises did not have this capability.

VIC C

Primary features. The distinguishing feature of VIC C was that it was a desktop computer system. The soldier manipulated a joystick, buttons, levers, and a touch screen to control all actions in the VE. In contrast with the other VICs, VIC C was not designed with the intent to have soldiers physically replicate actions on the battlefield as they would in the real world.

VIC C had three components: a computer screen that showed the VE to the soldier, a touch computer screen, and a control box. The touch screen allowed the soldier to select his weapon system and other capabilities, only some of which were used in the exercises. The control box had two levers, eight buttons (prone, kneel, stand, foxhole, assault, deploy, lase, and reset), and a joystick that the VIC soldier manipulated in order to move and fire in the VE. The touch screen controlled the sensors/sights and the weapon used by the soldier. In addition, it provided information to assist him in navigating and moving in the VE.

Movement and body positions. Four of the eight buttons on the control box specified the soldier's position: stand, kneel, prone, and foxhole. Foxhole was not played in the exercises. The VIC C soldier punched the appropriate button to assume the desired position. In addition, the touch screen displayed VIC C's icon in the selected position. This screen let the VIC C soldier verify his position. The touch screen also had a global positioning system, compass, and map capability. Soldiers often used these features to assist them in moving and navigating in the VE.

One lever (referred to here as Lever #1) allowed the soldier to move forward and backward; the midpoint was the stop point. This lever also controlled the speed of movement.

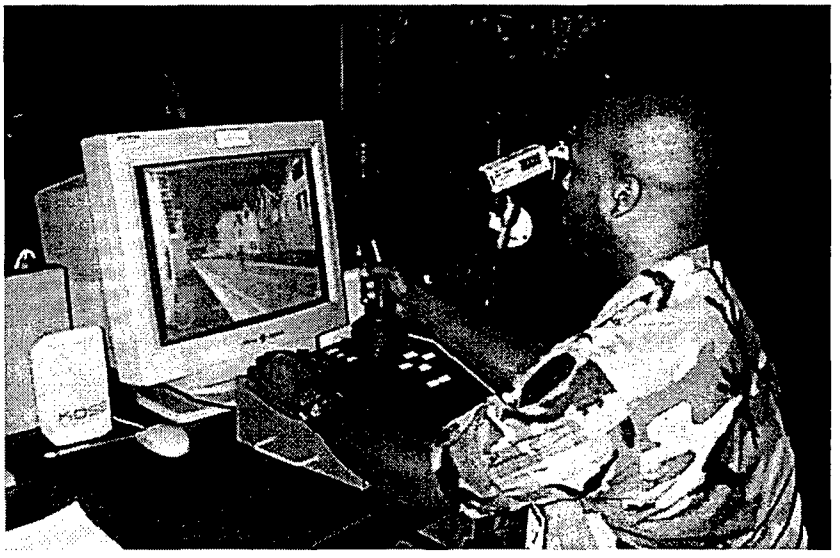

Figure 4. VIC C.

The soldier tilted the joystick to control the direction of movement. Movement in VIC C was affected by the terrain surface and automatically controlled. For example, the VIC C soldier went faster on the road than through the woods. To run or walk, the standing button was pushed and Lever #1 moved to the desired forward position. To crawl, the soldier punched the prone position button while Lever # 1 was in the forward movement position.

There was as assault button on the control box as well. It put the soldier automatically into an assault position in the VE when he stopped. Initially, VIC C was programmed so that the soldier went to a kneeling position within two seconds and then to prone in five seconds. During the exercises, however, the software was changed so the soldier went to prone immediately when the assault button was pushed. The weapon was always deployed in the assault mode.

In MOUT, the VIC C soldier could not enter buildings nor move in them, due to software limitations. A VIC C soldier could be positioned in a window or on top of a roof to provide fire support. During the MOUT exercises, the VIC C soldier typically provided fire support in a prone position outside the building that was to be cleared.

Shooting. To fire, the soldier had to first hit the deploy button. The soldier then fired by pulling a trigger on the joystick. For the M16 rifle, iron sights were displayed on the computer screen. For the SAW, the sight picture was a circle with crosshairs. Soldiers aimed by moving the joystick, and controlled the speed of movement of the sight picture with Lever #2 - the sensitivity lever. To fire from different positions, the soldier punched the stand, kneel, or prone buttons. Firing was also possible from the assault mode.

For VIC C, the M16 had a three-round burst; the SAW, a six- to nine-round burst. The soldier knew he was killed when blue sky appeared on the computer monitor. Ammunition restrictions could be played with the VIC C, but were not.

Another difference between VIC C and the other VICs was that the probability of killing the VIC C soldier was probabilistic. JANUS wargame algorithms were used to determine a kill given a hit.

Seeing. The VIC C soldier twisted the joystick to control the orientation of his head (left, right, up, and down). Scanning rate was controlled by Lever #2, the sensitivity lever. The reset button reset the soldier's head so it was aligned with the direction of his body. The VIC C soldier could scan in a direction different from the direction of movement as long as his weapon was not deployed. The soldier's field of view varied with the sensor: eyes - 45 degrees, rifle - 25 degrees. The field of regard was 360 degrees, accessed by turning body and head with the joystick. Resolution of the computer screen was 1280 by 1024.

Audio and soldier communication. The VIC C soldier used a headset and microphone to communicate with the other VIC soldiers. Speakers on top of each computer broadcast battlefield sounds.

Other background information. Approximately 32 hand and arm signals are possible with VIC C through a model known as Jack ML. But this capability was not used due to limitations of the DIS. Other capabilities, such as other sensors (binoculars, thermal weapon sight), other weapons, video capture, call for fire, laser range finder (lase button), and foxhole position (foxhole button) were also not used.

VIC User Exercise Objectives

The purpose of the User Exercises was to determine how well the VIC simulator systems met user needs in mission-oriented contexts. The primary focus of the User Exercises was to identify the strengths and weaknesses of the four VICs from the user perspective and to use these findings, in conjunction with the engineering data, to guide the development of future generation VICs and VIC system requirements in general.

Method

Participants

Participants were eight male soldiers from Fort Benning, GA. All soldiers had from one to five years in service time and were MOS 11M (Fighting Vehicle, Infantry) qualified. They were approximately 19 to 30 years in age. The sample was composed of two sergeants, three specialists, two PFCs, and one PV2. A staff sergeant, familiar with the VICs, was used to fill the role of an infantry squad leader.

Materials

Three questionnaires were administered to the participants at specified times during the exercise. Each of the questionnaires is described in the following paragraphs.

VIC Capability Assessment Questionnaire. The VIC Capability Assessment Questionnaire (Appendix A) assessed the difficulty of performing selected tasks on each VIC in

four areas, i.e., movement, orientation (of self and others), visual recognition (person, target, object), and weapon engagement. Tasks were rated using a four-point scale with the following anchor points: 1 = No opportunity to perform; 2 = Unable to perform; 3 = Could perform easily; 4 = Could perform with difficulty.

VIC Evaluation Questionnaire. The VIC Evaluation Questionnaire (Appendix B) required participants to rate each VIC across three dimensions for specific tasks. For the first dimension, participants were asked to rate how effective each VIC was for engaging targets, simulating movement, and for identifying objects, people, etc. For this dimension, a five-point scale was used: 1 = Very effective; 2 = Generally effective; 3 = Somewhat effective; 4 = Generally ineffective; 5 = Very ineffective. Next, participants were asked to rate the similarity between performing specific tasks in each VIC and performing the same tasks in the real world. Tasks included: moving over open, flat terrain; moving over hills and cross compartments; moving around and inside of buildings; weapon firing; and firing and moving as a team member. A three-point scale was used for this dimension: 1 = Very similar; 2 = Somewhat similar; 3 = Very dissimilar. Finally, soldiers were asked to compare how quickly they could engage targets, and recognize people, objects, and targets in each VIC versus performing these same tasks in the real world. A three-point scale was also used to rate this dimension: 1 = Quicker than a real weapon/in the real world; 2 = Slower than a real weapon/in the real world; 3 = About the same as a real weapon/in the real world.

VIC Comparison Questionnaire. The VIC Comparison Questionnaire (Appendix C) required the participants to rank order the VICs from 1 (Best) to 4 (Worst) on four dimensions, i.e., how many elements or aspects of a task could be performed; how easy it was to perform the specific tasks; the extent to which the VICs allowed the soldier to perform tasks in a tactically sound manner; and the realistic manner in which the VICs allowed one to perform the tasks. The VICs were ranked on eight tasks for each dimension.

VIC Observation Form. The VIC Observation Form (Appendix D) was used by observers (researchers) for each exercise scenario that was executed. This form was divided into separate sections with specific response options designed to structure the observations. Observers also had space on the form to note any critical incidents occurring during this time. Selected areas for observation included: methods used by the soldier to move; positions used in firing; and enemy engagement (e.g., Did the soldier see the enemy? Did the soldier see the enemy firing?).

Structured Interview. After completion of all exercise sessions, participants were also interviewed by the researchers on a one-on-one basis to clarify issues noted by the observers and to obtain specific information based on soldier experiences in the VICs and the different data bases. Nine questions were asked to all participants. They included the following:

- What were the best features of each VIC?
- What were the least desirable features of each VIC?
- In which VIC was the visual display most like the real world?
- In which VIC was the visual display least like the real world?
- What things need to be changed in the desert environment?

- What needs to be changed in the MOUT environment?
- How would you build a new and better VIC using features from the existing VICs?
- What new feature or capability would you add to improve individual performance?
- What new feature or capability would you add to improve team performance?

Visit to McKenna MOUT site. After the interviews, the soldiers were taken to the McKenna MOUT Site at Ft. Benning. The purpose of this excursion was to determine how the soldiers' perceptions of McKenna in the virtual world differed from their perceptions of the "real" McKenna. They were told of this excursion only after completing the interview. None had seen McKenna before. At the site they were asked whether they would have taken the same approach route as they did on their exercises, if the buildings appeared differently, and about any differences in how they would have executed the mission in the real world.

The data base for the McKenna MOUT Site was based on a high-resolution (one meter) mapping of the terrain (Institute for Defense Analysis, 1997). However, due to limits on computer capacity available for the user exercises, an exact portrayal of all features (e.g., vegetation) at the site was not possible.

Apparatus

Four virtual individual combatant simulators (VICs) were employed. Soldiers in each VIC could communicate with each other and their squad leader. The systems were integrated such that each soldier could see or do generally the same thing as what another soldier would see or do in another VIC. VIC C could not go or see inside buildings. VICs A, B, and F had this capability.

Design and Procedure

Training phase. The user exercises were conducted over a three-week period. The first week served primarily as a training period. During the first day, the soldiers were briefed on the purposes of the user exercises and given a brief description of each VIC and each VIC's major characteristics. Over the remaining days soldiers were given the opportunity to operate in each VIC in selected scenarios. The four VICs were linked to each other as a fire team which enabled them to act as part of a squad to conduct specific tactical operations. The exercise scenarios were based on a tailored infantry squad performing selected individual and collective tasks. The squad was composed of a mixed force of DI-SAF and VIC elements. One fire team (Alpha) was manned exclusively by DI-SAF generated entities. The second team (Bravo) was composed of the four VICs. The fire team consisted of a team leader, SAW gunner, and two riflemen.

The scenarios consisted of two general types with slight variations in each scenario to provide some variation across sessions. The scenarios based on the 29 Palms data base consisted of either an attack or defend mission. The attack scenarios employed two possible objectives. The defend scenario used only one possible objective. In both cases, the four VICs acted as a four-man fire team in conjunction with a four-man fire team generated by DI SAF.

During attack, the DI SAF fire team acted as the support element and the four VICs acted as the assault element. The enemy element always consisted of two DI SAF and one sniper, who was an actual person. The attack missions differed in terms of objective and direction of the movement of the two elements. Both elements would start from the same location. However, if the assault element was to attack, the route would begin to the right and circle toward the objective. At the same time the support element's route would begin to the left and then circle in toward the objective from the left. Therefore, there were two possible variations of the attack mission for each of the two objectives. There were times that the missions differed from the original plan. For example, there were at least two occasions where the support element (DI SAF) was lost because of a software problem resulting in the assault element having to attack without support.

The defend mission consisted of the two fire teams conducting a defense oriented to the north of the objective. The two elements were employed on a line on the forward slope of the objective. The enemy element was made up of two four-man fire teams of DI SAF conducting a frontal assault. Table 1 contains information for both the defend and the attack scenarios.

Table 1

29 Palms Scenarios

Scenario Name	Mission Description	Distance Information	Opposing Force Composition
Red	Attack objective from either the left or right side. A SAF fire team acted as support element on opposite side of the objective.	250 meters straight line distance to objective. Possible to remain concealed up to 70 meters from objective.	Two DI SAF and one sniper.
White	Attack objective from the right. A SAF fire team acted as a support element on the right. Terrain constraints caused the VIC fire team to attack from further out than the SAF.	250-300 meters straight line distance to objective. Attack became a frontal assault in full view about 75 meters from the objective.	Two DI SAF and one sniper.
Blue	Forward slope defense. DI SAF acted as one fire team either to the right or left side of the VIC fire team.	Enemy started attack from 350 meters out. They became visible at about 300 meters.	Two four-man DI SAF fire teams.

The MOUT scenarios consisted of a squad attack. The typical mission was for the assault element to attack and clear a building while the support element provided covering fire outside the building. The soldiers in the VICs always acted as the assault element and DI SAF acted as the support element. The enemy consisted of two DI SAF outside in the vicinity of the building and one sniper inside the building. There were two buildings that could serve as the objective with varying start locations. All together, there were eight possible scenarios (two buildings times direction of approach). Table 2 contains information about the possible MOUT scenarios.

Table 2

MOUT Scenarios

Scenario Name	Mission Description	Opposing Force Composition
Green	Attack building A from the south. DI SAF fire team acted as support element.	DI SAF fire team outside building A and one sniper inside building A.
Yellow	Attack building A from the west. DI SAF fire team acted as support element.	DI SAF fire team outside building A and one sniper inside building A.
Brown	Attack building A from the north. DI SAF fire team acted as support element.	DI SAF fire team outside building A and one sniper inside building A.
Black	Attack Building A from the east. DI SAF fire team acted as support element.	DI SAF fire team outside building A and one sniper inside building A.
Gold	Attack building B from the south. DI SAF fire team acted as support element.	DI SAF fire team outside building B and one sniper inside building B.
Copper	Attack building B from the west. DI SAF fire team acted as support element.	DI SAF fire team outside building B and one sniper inside building B.
Gray	Attack building B from the north. DI SAF fire team acted as support element.	DI SAF fire team outside building B and one sniper inside building B.
Orange	Attack building B from the east. DI SAF fire team acted as support element.	DI SAF fire team outside building B and one sniper inside building B.

The training runs were allotted 60 minutes (10 minutes for the team leader brief, 5 minutes to mount VICs, 15 minutes to execute the scenario, 5 minutes to dismount the VICs and 25 minutes for the AAR and ARI questionnaires). Since there were eight participants and four VICs the group was divided into halves. One participant from each group was paired with a specific VIC. Each pair rotated on and off their assigned VIC each hour. Once each participant had rotated through each position (leader/non-leader) for a given VIC and scenario, the pair then moved to another VIC and the procedure was repeated.

After each scenario or session was completed, participants reported back to the AAR room where the scenario was replayed on two monitors and feedback was provided by the squad leader. After a soldier had completed back-to-back scenarios in both a leader and non-leader position for a specific VIC, the soldier was administered both the VIC Capability and the VIC Evaluation Questionnaires. This was done only one time per soldier during this time, primarily as a means of piloting the instruments. Once all training scenarios were completed, the soldiers were then administered the VIC Comparison Questionnaire.

Each ARI staff member was assigned to different VICs (usually three) to observe for a given day. Observers did not stay with the same pair of soldiers as participants and observers were rotated through each VIC on different rotational schedules across the training phase.

User exercise phase. The exercise phase was very similar to the training phase, i.e., exercise runs were allotted 60 minutes and broken down as described above; soldiers were assigned to VICs in pairs and alternated their time in each VIC (one hour in and one hour out). Unlike during the training phase, the two sergeants always served as the team leader. The other soldiers rotated through the remaining positions (SAW gunner and rifleman - 2 positions). As was case during the training phase, following the completion of each scenario soldiers reported back to the AAR room where the scenario was replayed and feedback was provided by the squad leader. After a soldier had completed back-to-back scenarios for a specific VIC, he was administered both the VIC Capability and the VIC Evaluation Questionnaires following the AAR. After two sessions on a given VIC, the soldiers moved to another VIC and the procedure was repeated. Each participant completed three sessions per day.

Sixteen sessions were completed using the 29 Palms data base and sixteen sessions were completed using the MOUT data base. After completing their last session for a given data base, soldiers filled out the VIC Capability, VIC Evaluation, and the VIC Comparison Questionnaires.

Like the training phase, each ARI staff member was assigned to observe a different combination of VICs each day. Soldiers were also rotated, in a systematic basis, through specific VICs each day.

After completion of all exercises and questionnaires, soldiers were then interviewed individually by ARI staff members on selected issues concerning their experiences in the VICs and the different data bases (see pages 13 and 14 for questions asked during the interviews).

Results

VIC Comparison Across Tasks and Dimensions

Soldiers' rankings of each VIC from the VIC Comparison Questionnaire, given after all exercises were completed, were averaged for each of six non-leader tasks for each of four dimensions: flexibility (how many elements or aspects of a task could be performed); ease of performing tasks; the extent to which the VICs allowed the soldier to perform tasks in a tactically sound manner; and realism. The six non-leader tasks included: move as an individual; move as a member of a fire team; maintain situational awareness; recognize people, targets, and objects; engage targets as an individual; and engage targets as a member of a fire team.

Inspection of the mean rankings showed a strong halo effect. VIC B ranked best across the four dimensions: flexibility, ease, tactical soundness, and realism. VIC B was ranked as more flexible than the other VICs. VIC B was also ranked as the easiest with regard to performing selected tasks with the exception of the tasks "moving as an individual" and "moving as a member of a fire team". Soldier rankings also showed VIC B to be the best in terms of

enabling tasks to be performed in a tactically sound manner. Finally, VIC B was ranked the best when it came to allowing tasks to be performed in a realistic fashion. This pattern held, for the most part, across data bases, 29 Palms and MOUT. VIC A, was clearly the worst when it came to flexibility, ease, and tactical soundness while VIC C was ranked the worst for realism in the 29 Palms data base. In the MOUT data base, the rankings seemed to show VICs A and C as the two least preferred systems for each dimension (see Appendix E, Tables E1-E8). It should be noted that VIC C was severely limited in what it would allow the soldier to do in the MOUT scenarios.

For the leader tasks "controlling fire" and "controlling movement", the two team leaders ranked both VICs B and F as the best across dimensions with only a few exceptions. This pattern held across data bases (see Appendix E, Tables E1-E8).

The mean task rankings were collapsed across the four dimensions. Figures 5 and 6 show that VIC B was ranked the best with regard to performing the six non-leader tasks across data bases. For the 29 Palms data base, VICs C and F were the next preferred systems followed by VIC A. For the MOUT environment, VIC F appeared to be the next preferred system. This was followed by VICs A and C as the two least preferred systems in this environment.

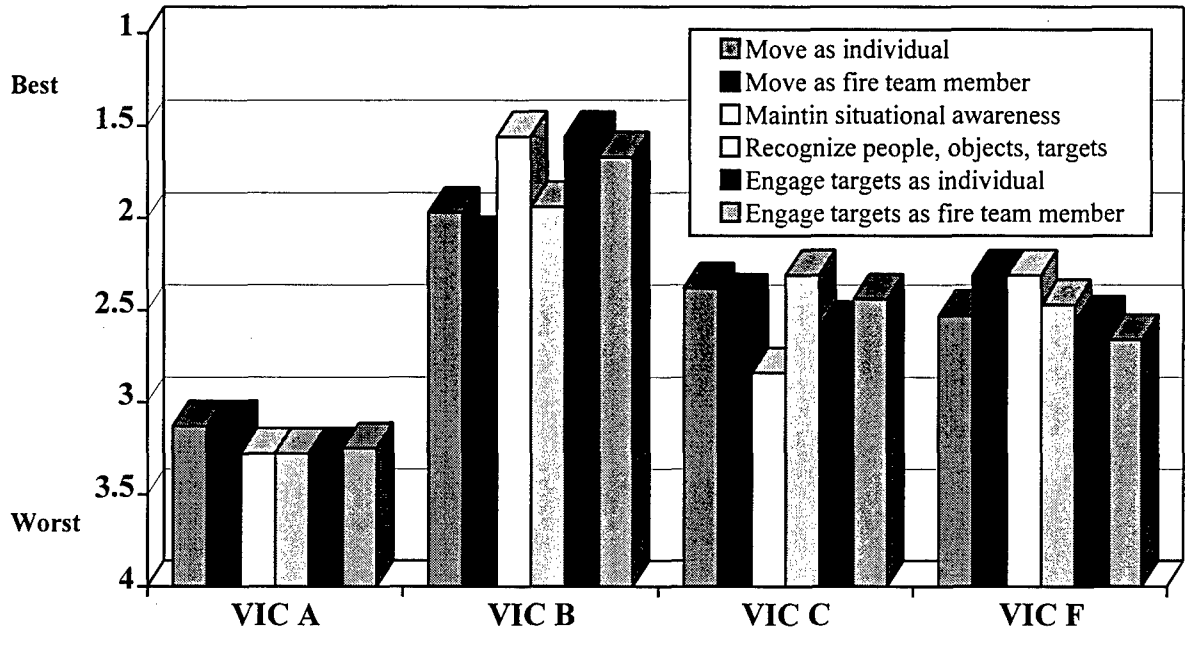

Figure 5. Mean rankings of each VIC by task collapsed across dimensions - 29 Palms.

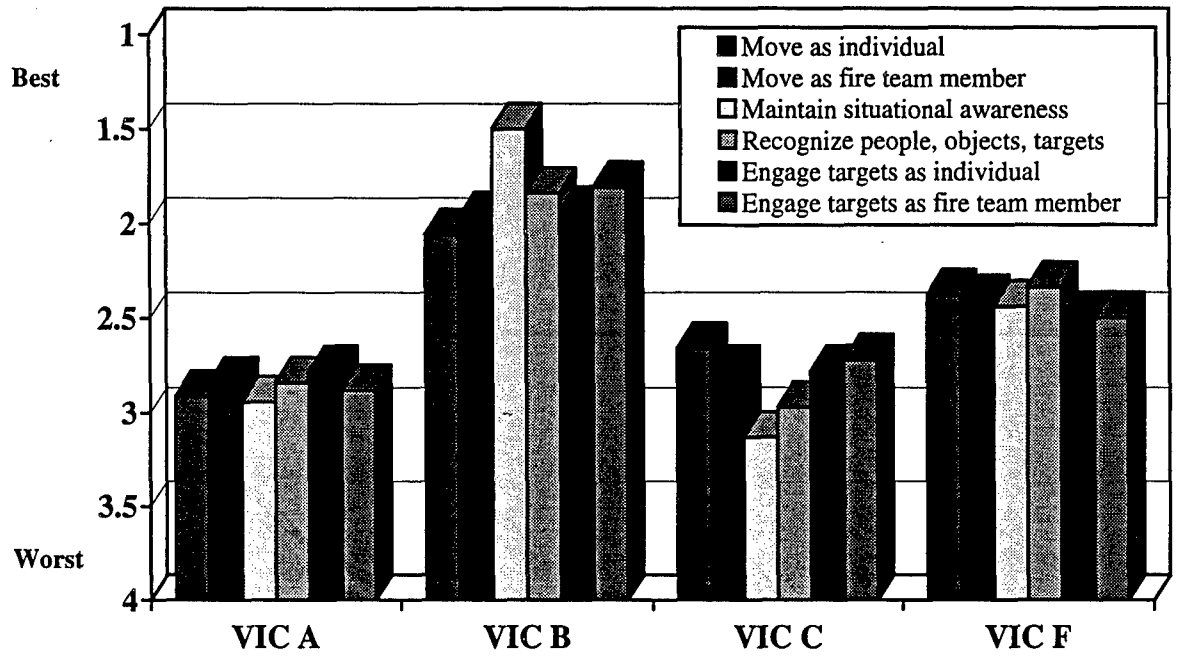

Figure 6. Mean rankings of each VIC by task collapsed across dimensions - MOUT.

A three-way within-group repeated measures ANOVA [environment (2) x VIC (4) x Task (6)] was computed, using, as the dependent measure, the soldier's average ranking of each VIC by task (collapsed across dimension). A significant effect for VIC was obtained, $F(3, 21) = 2.96$, $p = .05$. Subsequent post-hoc comparisons (Newman-Keuls) indicated that while soldiers' rankings of VIC B showed that they performed tasks significantly better (in terms of greater flexibility in performing tasks, ease of performance, tactical soundness, and realism) in VIC B, only the differences between VICs B and A were statistically significant.

VIC Evaluation

Soldiers' ratings of the VICs across specific areas were averaged and are presented in Figures 7-11. The areas that were rated included: effectiveness of the VICs for engaging targets, simulating movement, and identifying objects and people; similarity of tasks performed in VICs to real world performance; and quickness in engaging targets and recognizing people, objects and targets in VICs compared to real world performance of the same tasks. Key findings are presented in the following sections. Other than summary statistics, no statistical tests were computed since not all of the soldiers responded to every item in the questionnaire. Cell size varied from 3 to 8 across items. As a consequence, the patterns of results described below should be interpreted cautiously. Tables containing the exact n and percentage per item category are presented in Appendix F, Tables F1-F17.

Effectiveness of VICs for engaging targets, simulating movement, and identifying objects and people. Figure 7 shows that for the 29 Palms data base, VICs B and C were rated by respondents as the most effective with regard to engaging targets and identifying objects. VICs B, C, and F were rated the most effective with regard to simulating movement. VIC F was rated

as the least effective system for engaging targets. VICs A and F were the least effective for identifying objects.

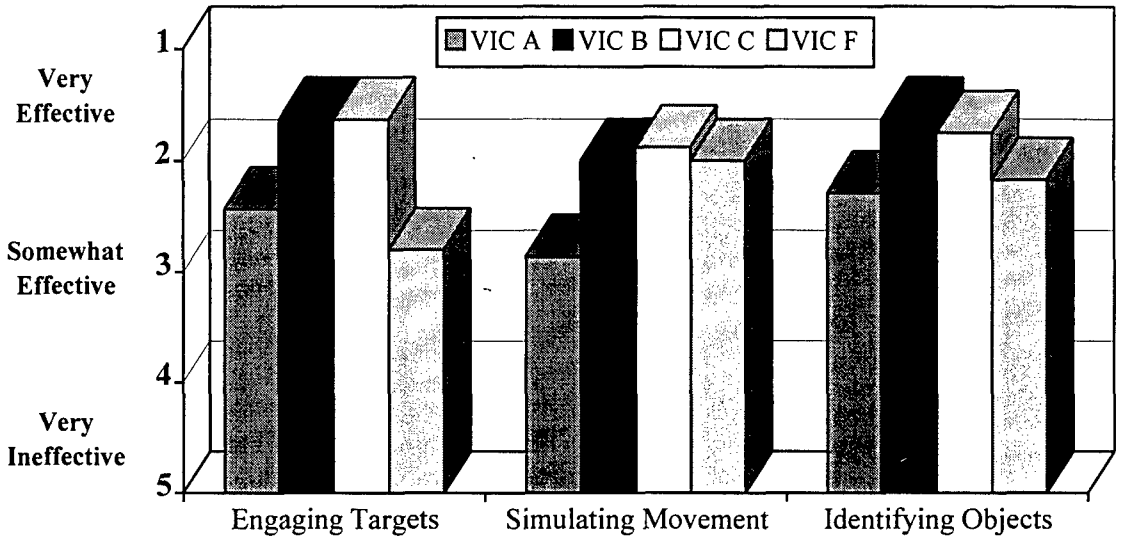

Figure 7. Effectiveness ratings by VIC for engaging targets, simulating movement, and identifying objects and people - 29 Palms.

For the MOUT data base VIC C was rated by respondents as the most effective for engaging targets followed by VIC F. All VICs appeared to be at least somewhat effective with regard to simulating movement. Similarly, all VICs appeared to be at least generally effective in identifying objects (see Figure 8).

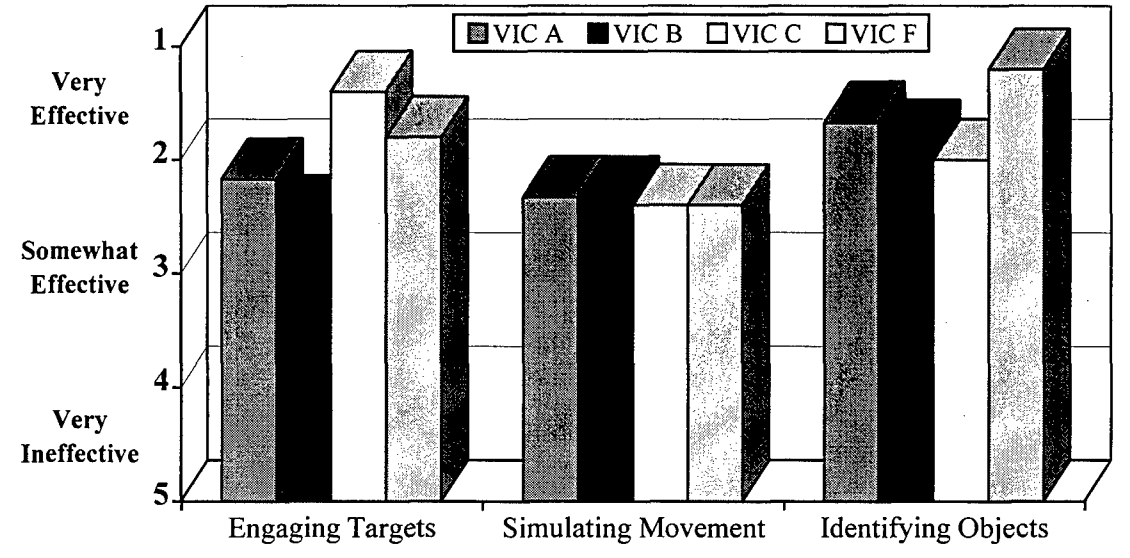

Figure 8. Effectiveness ratings by VIC for engaging targets, simulating movement, and identifying objects and people - MOUT.

Overall, as can be seen from both Figures 7 and 8, all systems were rated at least somewhat effective with regard to performing these three tasks.

Similarity of tasks performed in VICs to real world performance. Respondents' ratings indicated that for the 29 Palms data base, moving over open, flat terrain and moving over hills and cross compartments were most similar to real world performance of the same tasks in VICs B and C. VIC F was rated slightly less realistic for movement. Movement was least like real world performance in VIC A. Weapon firing in VIC F was clearly rated the most similar to real world performance of all the VICs. The remaining VICs were rated about the same with regard to similarity of weapon firing to real performance. Firing and moving as a team member was rated by respondents as most similar to real world performance for VICs B and C and least like real world performance for VIC A (see Figure 9).

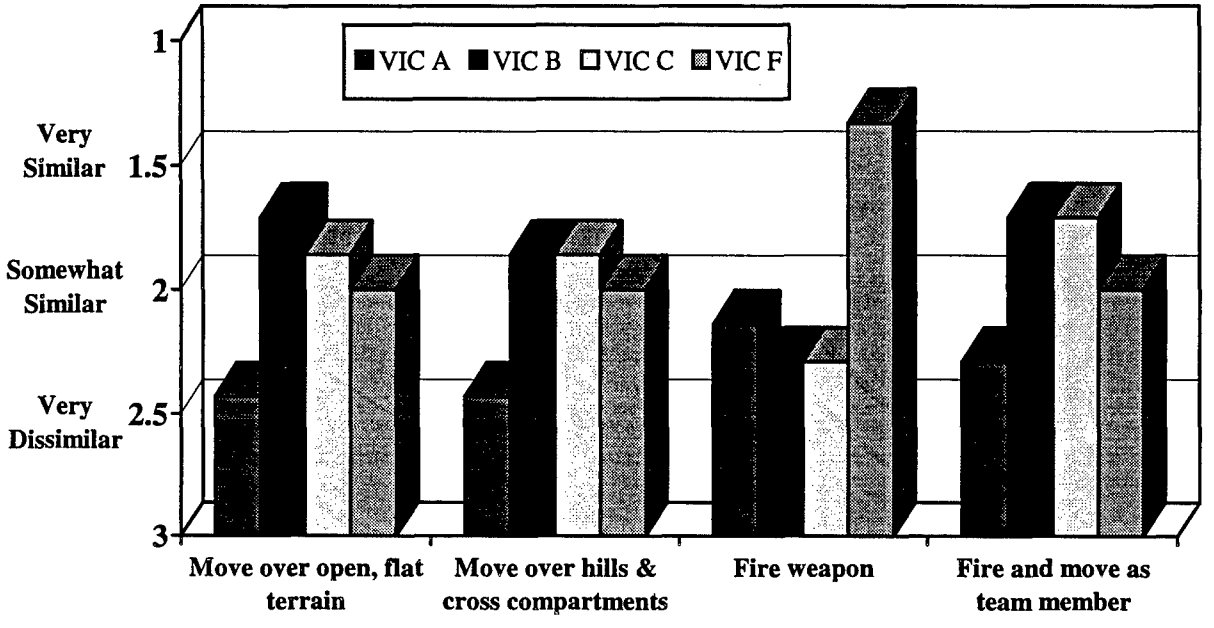

Figure 9. Extent to which tasks performed in VICs are similar to real world performance – 29 Palms.

For the MOUT data base, VIC C was rated by respondents as being the most dissimilar to real world performance for moving around and inside of buildings, weapon firing, and firing and moving as a team member. These ratings are most likely due to the fact that VIC C was not set up to permit soldiers to see, shoot and move around inside of buildings as was the case for the other VICs. VIC F was rated as being most similar to the real world with regard to moving around and inside of buildings, followed by VIC B. Weapon firing was clearly rated as being the most similar to real world performance in VIC F. Firing and moving as a team member paralleled real world performance most closely in VIC B followed by VIC F (see Figure 10).

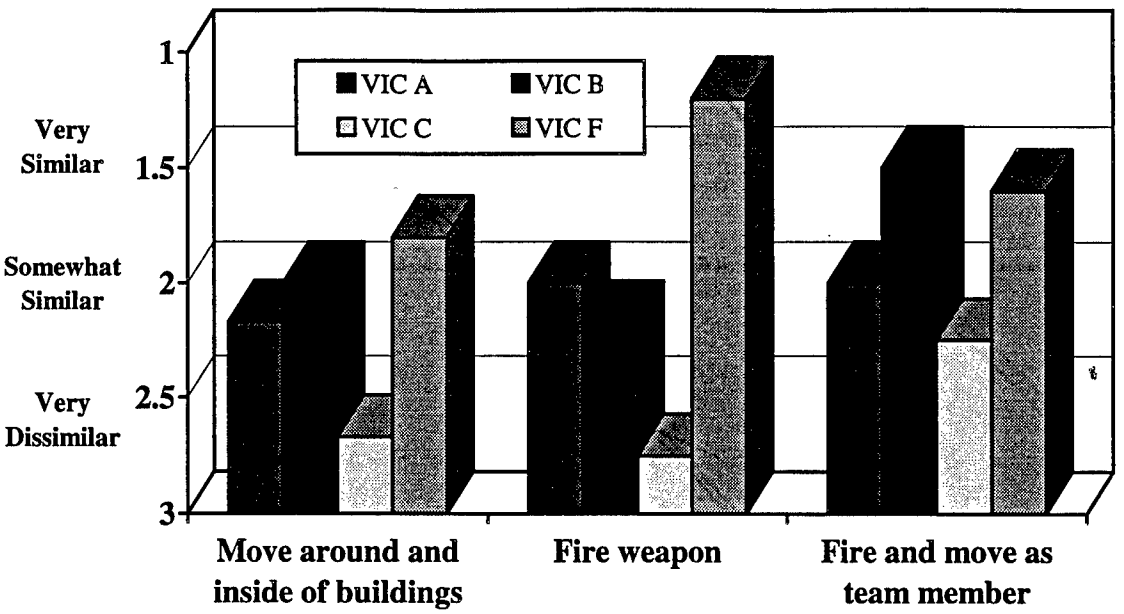

Figure 10. Extent to which tasks performed in VICs are similar to real world performance – MOUT.

Quickness in engaging targets. Ratings for engaging targets in the 29 Palms data base showed that VIC C was closest to real world performance. That is, respondents indicated that they could engage targets about as quickly in VIC C as they could if they were using a real weapon. In contrast, VIC A was rated as the slowest of all the VICs. Respondents unanimously rated VIC A as being slower than a real weapon for engaging targets. Ratings for VICs B and F were similar; more like the real world than VIC A, but falling slightly below the ratings given for VIC C (see Figure 11).

For the MOUT environment, respondents' ratings indicated that engaging targets was closest to real world performance, i.e., same as using a real weapon, in VIC F. Ratings for VICs A, B, and C, were lower than for VIC F and generally comparable, indicating that engaging targets while operating these VICs was somewhat slower than using a real weapon (see Figure 11).

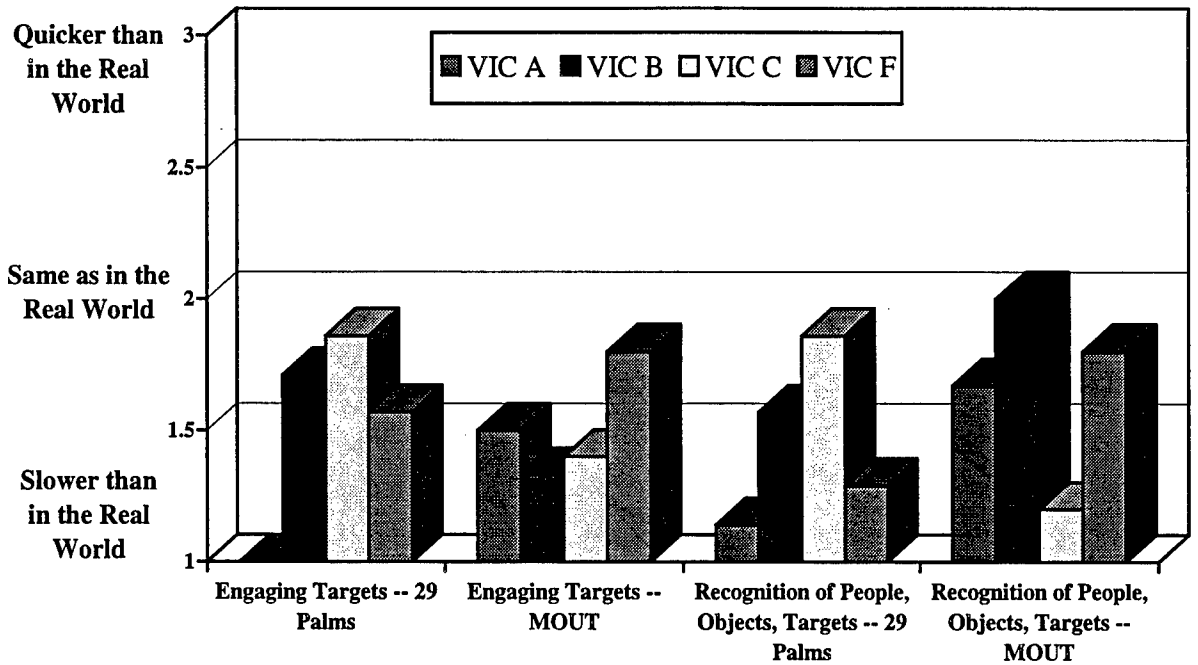

Figure 11. Quickness in engaging targets and recognizing people, objects, and targets by VIC and by data base.

Quickness in recognizing people, objects, and targets. For the 29 Palms data base, respondents' ratings showed that recognizing people, objects, and targets was closest to real world performance in VIC C, i.e., this task could be accomplished in about the same amount of time as it would take in the real world. VIC B was rated as the next most realistic with regard to performing this task. VIC A was rated as the slowest for recognizing people, objects, and targets, followed by VIC F (see Figure 11).

For the MOUT data base, VIC B was rated as the most realistic with regard to recognizing people, objects, and targets. The majority of respondents indicated that they could perform this task (in VIC B) in about the same amount of time as it would take in the real world. VIC C was rated the slowest for recognizing people, objects, and targets. This, again, could be due to the limitations in the system as noted earlier (see Figure 11).

VIC Capability Assessment

The objective of the VIC Capability Questionnaire was to assess the extent to which soldiers were able to perform selected tasks, and the level of difficulty involved in performing these tasks. Tasks fell in to four main categories: movement, orientation, visual recognition, and weapon engagement. Task difficulty ratings are presented in Appendix G, Tables G-1 – G-36. As was the case for the VIC Evaluation Questionnaire, sample sizes varied over tasks. This was due to some soldiers not answering selected items and to other soldiers having no opportunity to perform the tasks. To help provide a less ambiguous picture of the capabilities of each VIC, simple frequency counts were computed for each time a soldier indicated that he was unable to perform a specific task in a specific VIC and broken down by data base (29 Palms versus MOUT). Similarly, frequency counts were computed for those tasks which the soldier indicated that he had difficulty performing and were broken down by VIC and by data base (see Tables 3 and 4).

Tasks most frequently identified as being unable to be performed. For the 29 Palms data base, 40 separate occurrences were noted in which soldiers indicated they were unable to perform a specific task. The tasks most frequently mentioned fell under the categories weapon engagement ("detect enemy fire" – 11 occurrences) and visual recognition ("detect enemy soldiers" – 6 , and "estimate distance to other personnel " – 4). For the first two tasks, the inability to perform theses tasks occurred across all four VICs (but VIC B most often with five occurrences for detect enemy fire). For the third task, "estimate distance to other personnel", occurrences were noted for three of the VICs. The most incidents reported of being unable to perform a specific task occurred in VICs B (13) and F (15). (See Table 3). Appendix G, Tables G-37 – G-40, summarizes the findings for all tasks by task category and by database.

Table 3

Task Categories Identified as Unable to be Performed by VIC and by Data Base

TASK CATEGORY	VIC				Total Instances by Task Category
	A	B	C	F	
29 PALMS					
Movement	1	0	0	0	1
Orientation	0	3	0	3	6
Visual Recognition	4	5	4	5	18
Weapon Engagement	2	5	1	7	15
Total Instances by VIC	7	13	5	15	40
MOUT					
Movement	0	3	6	0	9
Orientation	0	0	4	0	4
Visual Recognition	3	2	2	2	9
Weapon Engagement	3	2	2	2	9
Total Instances by VIC	6	7	14	4	31

For the MOUT data base, 31 separate occurrences were noted in which the soldiers indicated that they were unable to perform a specific task. The tasks most frequently mentioned fell under the categories of weapon engagement ("detect enemy fire" – 7 occurrences) and movement (enter a door, window, or hole – 5 "; and " move around and inside of buildings" – 4). For "detect enemy fire", occurrences were noted across all VICs. It is important to note that for the movement tasks "enter a door, window, or hole" and "move around and inside of buildings", six of the nine reported occurrences came from VIC C, which did not have the capability to go into and or move around inside of buildings. Ignoring those MOUT tasks that could not be performed in VIC C, Table 3 shows that soldiers were no less able to perform tasks in one VIC than in another VIC.

Table 4

Task Categories Identified as Performed with Difficulty by VIC and by Data Base

TASK CATEGORY	VIC				Total Instances by Task Category
	A	B	C	F	
29 PALMS					
Movement	3	6	1	1	11
Orientation	7	8	2	3	20
Visual Recognition	15	18	17	14	64
Weapon Engagement	6	5	6	2	19
Total Instances by VIC	31	37	26	20	114
MOUT					
Movement	4	3	3	0	10
Orientation	5	3	5	1	14
Visual Recognition	8	4	7	3	22
Weapon Engagement	3	4	2	3	12
Total Instances by VIC	20	14	17	7	58

Tasks most frequently identified as being difficult to perform. For the 29 Palms data base, 114 separate occurrences were noted. The majority of tasks that soldiers identified as being difficult to perform were visual recognition tasks (64 occurrences). For the most part, difficulties in performing these tasks were not related to any specific VIC. Overall, however, VIC B had the most occurrences (37), i.e., number of times respondents indicated a given task was difficult to perform, and VIC F had the fewest occurrences (20) (see Table 4).

As can be seen from Table 4, the MOUT data base had only about half the occurrences (58) as the 29 Palms data base, indicating that tasks were easier to perform in the MOUT environment. Approximately 37% of the difficult tasks were visual recognition tasks. Overall, VIC A had the most recorded incidents (20) in which respondents identified a specific task as difficult to perform. VIC F had the fewest occurrences (7). There was some inconsistency in the findings. Despite VIC C's inability to go into buildings and rooms, some respondents indicated that they could move, with difficulty, around and inside of buildings; enter a door, window, or hole; move through a building knowing which rooms are cleared; and determine where team members are around and inside of buildings.

Chi-square tests were run to determine if there was any significant relationship between the frequency with which respondents indicated they were either unable to perform or who could perform tasks with difficulty and type of VIC. The results showed no statistically significant relationship between frequency of occurrence and VIC.

VIC Observations

Results from the staff observations of the VICs during the exercises were summarized and are presented in Tables 5-8. The results were broken down into four areas: movement, fire

positions, enemy engagement, and system integrity. Of primary interest are the enemy engagement and system integrity findings which are discussed in the following sections.

Enemy engagement. In the 29 Palms data base, soldiers saw the enemy in only 33 to 44% of the scenarios observed for VICs A, B, and C. In contrast, soldiers saw the enemy in 54% of the scenarios in VIC F (see Table 5).

Table 5

Enemy Engagement by Category and VIC - 29 Palms

ENEMY ENGAGEMENT	VIC A		VIC B		VIC C		VIC F	
	n[a]	%	n[b]	%	n[c]	%	N[d]	%
Saw Enemy	**5**	**33**	**7**	**41**	**7**	**44**	**6**	**54**
Saw Enemy Firing	**2**	**13**	**5**	**29**	**3**	**20**	**0**	**0**
Fired at Enemy	**5**	**33**	**9**	**53**	**7**	**44**	**5**	**46**
Was Killed	**12**	**80**	**11**	**69**	**10**	**63**	**8**	**73**
Was Killed Standing	5	33	4	25	2	13	1	9
Was Killed Kneeling	2	13	1	6	1	6	3	27
Was Killed Prone	5	33	6	38	7	44	4	36
Position Unknown	0	0	0	0	0	0	0	0
Survived Engagement	**3**	**20**	**5**	**31**	**6**	**37**	**3**	**27**
Standing	0	0	0	0	1	6	2	18
Kneeling	2	13	0	0	0	0	0	0
Prone	1	7	3	19	4	25	1	9
Position Unknown	0	0	2	13	1	6	0	0

Note. n = number of scenarios in which that specific incident was observed.
[a]N = 15. [b]N = 17. [c]N = 16. [d]N = 11.

Soldiers rarely saw the enemy firing. The percentage of scenarios in which soldiers saw enemy fire ranged from zero in VIC F to 29% in VIC B.

The percentage of scenarios observed in which the soldier actually fired at the enemy ranged from 33% for VIC A to 53% for VIC B. The percentages for VICs C (44%) and F (46%) fell in between these two systems.

In the MOUT data base, soldiers saw the enemy in over 80% of the scenarios observed for VICs B (90%) and F (84%). In contrast, the enemy was seen by the soldiers in only 21% of the scenarios for VIC C.

The soldiers saw the enemy firing in (63%) of the scenarios observed in VIC B. In only 32% of the scenarios in VIC F and 24% of the scenarios in VIC A did soldiers actually see the enemy firing. No reports of soldiers seeing the enemy firing were noted in VIC C.

Soldiers fired at the enemy in almost 80% of the scenarios observed in VICs B and F. In contrast, soldiers in VIC A fired at the enemy in 35% of the scenarios and in only 16% of the scenarios that were observed for VIC C.

Table 6

Enemy Engagement by Category and VIC – MOUT

ENEMY ENGAGEMENT	VIC A		VIC B		VIC C		VIC F	
	n[a]	%	n[b]	%	n[c]	%	N[d]	%
Saw Enemy	**7**	**41**	**17**	**90**	**4**	**21**	**16**	**84**
Saw Enemy Firing	**4**	**24**	**12**	**63**	**0**	**0**	**6**	**32**
Fired at Enemy	**6**	**35**	**15**	**79**	**3**	**16**	**15**	**79**
Was Killed	**7**	**41**	**11**	**58**	**3**	**16**	**9**	**47**
Was Killed Standing	7	41	11	58	0	0	9	47
Was Killed Kneeling	0	0	0	0	0	0	0	0
Was Killed Prone	0	0	0	0	3	16	0	0
Position Unknown	0	0	0	0	0	0	0	0
Survived Engagement	**10**	**59**	**8**	**42**	**16**	**84**	**10**	**53**
Standing	10	59	8	42	4	21	10	53
Kneeling	0	0	0	0	3	16	0	0
Prone	0	0	0	0	9	47	0	0
Position Unknown	0	0	0	0	0	0	0	0

Note. n = number of scenarios in which that specific incident was observed.
[a]N = 17. [b]N = 19. [c]N = 19. [d]N = 19.

Soldiers were less likely to be killed in the MOUT scenarios than in the 29 Palms scenarios. In the 29 Palms data base, soldiers were killed in the majority of scenarios observed, ranging from 63% in VIC C to 80% of the scenarios in VIC A (see Table 5). In MOUT, the highest number of casualties occurred while the soldiers were in VIC B. Soldiers were killed in 58% of the scenarios observed for this system. The percentages dropped to 47% in VIC F and 41% in VIC A. Due, in large part, to the configuration of VIC C, soldiers were killed in only 16% of the scenarios observed for this system (see Table 6).

System integrity. For the 29 Palms data base, VIC C was fully operational over the largest percentage of scenarios observed (82%). This was followed by VIC B, which was fully operational 71% of the time. VICs A and F were fully operational for only 47% of the scenarios observed. For VIC A, the primary reason for system malfunction was the constant recalibration required, which resulted in frequent delays in completing the scenarios. Malfunctioning in VIC B centered around the treadmill, weapon, and visual/graphics subsystems. Total system failure was noted in VIC F for 35% of the scenarios observed. The source of this failure was a malfunction in VIC F's weapon system, that shut the entire system down for approximately two days. VIC A was totally shutdown for 12% of the scenarios observed (see Table 7).

Table 7

System Integrity by VIC During the 29 Palms Scenarios

System Integrity	VIC A		VIC B		VIC C		VIC F	
	N	%	n	%	n	%	n	%
SYSTEM FULLY OPERATIONAL	**8**	**47**	**12**	**71**	**14**	**82**	**8**	**47**
SYSTEM MALFUNCTION								
• Calibration	6	35	0	0	0	0	0	0
• Movement	0	0	2	12	0	0	0	0
• Weapon	1	6	1	6	1	6	0	0
• Visuals/Graphics	0	0	1	6	1	0	0	0
• Communication/Audio	0	0	0	0	0	6	0	0
• Environment/Surroundings	0	0	0	0	1	6	1	6
• Unspecified System Malfunctions	0	0	1	6	0	0	2	12
SYSTEM FAILURE	**2**	**12**	**0**	**0**	**0**	**0**	**6**	**35**

Note. n = number of scenarios in which that specific incident occurred. Seventeen scenarios were observed for each VIC.

For the MOUT data base, VIC F was fully operational in 90% of the MOUT scenarios observed (see Table 8). VIC C was the next most reliable (fully operational) in 79% of the scenarios observed. Least reliable were VICs B (60%) and A (45%). The primary

Table 8

System Integrity by VIC During the MOUT Scenarios

System Integrity	VIC A		VIC B		VIC C		VIC F	
	n	%	n	%	N	%	n	%
SYSTEM FULLY OPERATIONAL	**9**	**45**	**12**	**60**	**15**	**79**	**18**	**90**
SYSTEM MALFUNCTION								
• Calibration	6	30	0	0	0	0	0	0
• Movement	0	0	1	5	0	0	0	0
• Weapon	0	0	1	5	1	5	1	5
• Visuals/Graphics	0	0	1	5	1	5	0	0
• Communication/Audio	0	0	0	0	1	5	0	0
• Environment/Surroundings	3	15	4	20	0	0	0	0
• Unspecified System Malfunctions	0	0	0	0	1	5	1	5
SYSTEM FAILURE	**2**	**10**	**1**	**5**	**0**	**0**	**0**	**0**

Note. n = number of scenarios in which that specific incident occurred. Twenty scenarios were observed for VICs A, B, and F. Nineteen were observed for VIC C, as it was excluded from one exercise for VIP demonstration.

problem with VIC A was the frequent recalibration required of the system. Total system failure was infrequent. The largest number of total system failures noted occurred in VIC A. However, this system was totally shutdown in only 10% of the scenarios observed.

Appendix H, Tables H-1 – H-4, summarize methods of movement and firing positions used in each VIC, arranged by environment (i.e., 29 Palms versus MOUT).

VIC Interview Results

Responses from the soldier interviews were first organized by question and by VIC and are presented in Appendix I. The responses were further refined and the key points extracted. These points were organized by area (move, shoot, communicate, maintain situational awareness, realism, and miscellaneous) and by VIC and are presented in Tables 9 - 12. The major points are summarized briefly in the following sections.

Best Features of VICs

The best features of each VIC are listed in Table 9. Inspection of the table suggests several themes in the soldiers' responses. Overall, soldiers appeared to like those features, which they regarded as realistic. For example, soldiers liked the realistic feel of the treadmill, specifically, the changing resistance as they went from flat to mountainous terrain and the fact that they had to actually walk to move. However, they also liked the quickness and ease which some VICs allowed them to move as in VICs C, F, and A (to a degree). Soldiers especially liked the feel of using a real weapon (VIC F). In addition, some soldiers liked the extra features on some VICs, e.g., the map, binocular, and compass features available on VIC C. Reliability was also mentioned as a key overriding feature which a VIC system should possess.

Least Desirable Features of VICs

The least desirable features of each VIC are listed in Table 10. Features regarded as least desirable were in many respects the mirror opposite of the factors noted above as being most desirable. Soldiers did not like features that they regarded as unrealistic. Moving and shooting with a joystick (VIC C) were seen as very unrealistic by soldiers and not particularly liked. Systems whose features were difficult to control, cumbersome, or difficult to perform were not well received. For example, as much as the soldiers liked the realistic aspects of VIC B's treadmill, they did not like the difficulty involved in controlling movement or being tethered by the harness. Similarly, although they liked the ease with which they could move in VIC F, they did not like the fact that they could not efficiently control the movement speed in this VIC. Unreliability, as a whole, was viewed by the soldiers as a very undesirable characteristic. VIC A which had some positive features, e.g., immersion-like quality of the system, untethered to wires, cables, etc., real-time movement of visuals, realistic target engagement, was frequently shutdown for recalibration, which was very frustrating to the soldiers.

Table 9

Best Features of Each VIC

AREA	VIC A	VIC B	VIC C	VIC F
Move	▪ Realistic movement ▪ Easy to move upstairs in MOUT.	▪ Appropriate resistance to different terrain. ▪ Closest to real world movement. ▪ Able to move sideways & side step corners.	▪ Movement easy, like video game.	▪ Quick, easy movement. ▪ Able to move backwards. ▪ Move head to change directions. ▪ Able to approach, but not go through walls.
Shoot	▪ Target engagement like real world. ▪ Able to hold rifle up & aim. ▪ Heads up display did not get in the way.	▪ Able to see where the rounds are going in MOUT. ▪ Reticle lights up when on target. ▪ Realistic weapon manipulation. ▪ Weapon accurate. ▪ Able to see & fire around corners.	▪ Clear visuals, easy ID of personnel. ▪ Easy to aim/shoot using joystick. ▪ Accurate aiming/ shooting. ▪ Quick engagement of targets. ▪ Able to select from variety of weapons.	▪ Actual weapon. ▪ Able to see where rounds are going/ look around corners in MOUT. ▪ Able to realistically aim/manipulate weapon. ▪ Tracers used.
Com-mun-icate	▪ No responses.	▪ No responses.	▪ Microphone. ▪ System quietness.	▪ No responses.
Maintain Situational Awareness	▪ Could distinguish team members. ▪ Able to look around corners. ▪ Quick reaction possible. ▪ Real-time movement of visuals.	▪ 360° view. ▪ Larger field of view. ▪ Able to look over shoulder (peripheral vision). ▪ Increased awareness of team member activities. ▪ Indirect visual capability of weapon.	▪ Able to determine body position. ▪ Able to see OPFOR in 29 Palms. ▪ Able to determine movement speed and direction.	▪ Movement of head to quickly change directions. ▪ Able to look around corners. ▪ Good peripheral vision. ▪ Able to maintain awareness of team member's activities.
Realism	▪ Headset provides realistic sensation. ▪ Able to see your hands. ▪ View bounces with movement, like being untethered. ▪ Helmet-like feel of headgear. ▪ Carry LBE.	▪ Rated as most realistic – aim of weapon, screen set-up, ODT. ▪ Able to estimate distance and determine dead space.	▪ Able to determine body position. ▪ Able to change positions quickly.	▪ Realistic size of objects. ▪ Realistic interaction with graphics. ▪ Requires real-world movement to kneel/go prone.
Miscell-aneous	▪ Floor compass directions. ▪ Immersion-like quality of system.	▪ System reliability. ▪ Approximated real training.	▪ Map, binoculars, and compass available.	▪ No responses.

Table 10

Least Desirable Features of Each VIC

AREA	VIC A	VIC B	VIC C	VIC F
Move	▪ Frequent recalibration. ▪ Unable to step backwards. ▪ Difficult to change or maintain speed. ▪ Difficult to determine movement speed.	▪ Difficulty stopping. ▪ Movement slow. ▪ Difficult to move in straight line. ▪ Difficult to move as team member. ▪ Directional movement difficult. ▪ Physically tiring.	▪ May be difficult for left-handed people to use joystick (due to positioning of controls). ▪ Joystick movement too sensitive.	▪ Movement speed difficult to control. ▪ Difficult to crawl. ▪ Difficult to move in buildings.
Shoot	▪ Frequent recalibration. ▪ Weapon sight not like M16. ▪ Weapon image "jittery"/ would jump. ▪ Difficult to aim/ recognize targets.	▪ Weapon weight incorrect. ▪ Difficult to determine dead space. ▪ Difficult to keep one eye on screen and one on IHAS.	▪ Difficult to recognize people/objects. ▪ Did not have weapon, only reticle on screen. ▪ Aiming unrealistic/ difficult (joystick).	▪ Calibration/aim inaccurate. ▪ Shooting from prone difficult/slow. ▪ Cannot play weapons other than M16.
Communicate	▪ Difficulty hearing. ▪ Must hold microphone to speak.	▪ Treadport loud – hearing/communications difficult.	▪ No response.	▪ No response.
Maintain Situational Awareness	▪ Difficult to identify distant objects/ people. ▪ Difficult to stay aware of team's activity. ▪ Only 45° field of vision. ▪ Poor peripheral vision/depth perception.	▪ No response.	▪ Difficult to determine distance from objects. ▪ Easy to become disoriented. ▪ No peripheral vision.	▪ Unable to detect enemy in 29 Palms.
Realism	▪ Unable to go prone/ often unable to kneel. ▪ Often able to walk through walls. ▪ Worst from tactical perspective.	▪ Tether attachment produced "jerky" movement. ▪ Harness is restricting/ unnatural. ▪ Weapon deployment unrealistic.	▪ Not realistic – more like video game (joystick). ▪ Weapon system unrealistic.	▪ Tactical positions problematic. ▪ Movement unrealistic.
Miscellaneous	▪ Screen jumps (29 Palms). ▪ Multiple system malfunctions.	▪ Odor from oil. ▪ Difficult to maintain balance. ▪ System too sensitive to hip movements.	▪ Unable to enter buildings.	▪ Screen moves faster/slower depending on direction of head movement. ▪ Cords to rifle, headgear get in the way when turning head.

General Comments About the Visual Display Systems Used by Different VICs

The majority of the soldiers liked VIC B the best. They indicated that the individual had a full 360 degree view (or at least 260) and that things are usually there when you look for them, unlike the other systems, in which, when the individual turns his head and then back, things disappear and you have to wait for them to reappear. Soldiers particularly liked the active involvement required of the individual in VIC B, i.e., the fact that one had to do something to make the system go. Some soldiers thought that VICs B and F were the best because they provided the most realistic display, particularly the large screen in VIC F, which portrayed the size of buildings and soldiers quite realistically. Some soldiers mentioned VIC C, primarily the map option, which allowed them to navigate the terrain easier.

The majority of soldiers indicated that VIC C had the least realistic visual display. Soldiers mentioned the limited visual angle provided by VIC C and poor distance estimation. While it was easy to aim using this system, this feature was almost completely negated by the video game feel of this VIC and the absence of holding a real weapon. As was noted above, the joystick feature of VIC C was seen as very unrealistic, and, together, with the toggling component, was not viewed as the optimal way to simulate behavior or effort needed to move or shoot in the real world. Finally, the inability of VIC C to go into buildings was viewed as another negative feature of this system.

Building a New VIC Using Features from Existing VICS

Soldiers were asked to identify those features of the current VICs that should be considered in developing future VIC simulator prototypes. The major points are presented in Table 11.

Move. The prototype VIC should have some type of ODT system which would simulate real-time movement and be physically demanding based on the terrain characteristics (VIC B). It should be easier to control, with the harness mechanism, currently used in VIC B modified or eliminated. The prototype VIC should allow the soldier to actually assume the kneeling and prone positions like VIC F. The mobility aspects of VIC A, e.g., untethered, should be incorporated in the new VIC.

Shoot. According to the soldier responses, with regard to weapon characteristics, the new VIC should use a weapon with realistic weight, balance, etc. (VIC F). Actual weapon sights should be used (VIC F). Soldiers indicated that the ideal weapon system should have the indirect scanning/firing capability but not include the IHAS (VIC B). They liked having the eyepiece camera mounted on the weapon (VIC B). The prototype weapon system should have a weapon selection option as in VIC C so different weapon systems can be played, in addition to providing the soldier with a reticle (VIC C) and the use of binoculars (VIC C). Another desirable characteristic was to be able to have a system where the soldier could see where the rounds are landing (VIC F). Soldiers also indicated that including a screen mounted on a headset (VIC A) but with peripheral vision would be a desirable addition to the new prototype weapon system.

Table 11

Features of Current VICs to Incorporate in New VIC

AREA		VIC A	VIC B	VIC C	VIC F
Move	Use	▪ Mobility. ▪ Quick reaction characteristics. ▪ Head movement.	▪ Real-time movement. ▪ Maintain physical demand.	▪ No response.	▪ Movement speed. ▪ Kneel and prone methods.
	Add/Modify	▪ Include ability to determine movement direction. ▪ Include ability to show movement.	▪ Modify ODT – decrease noise and make it more responsive to sudden stops. ▪ Modify harness.	▪ No response.	▪ No response.
Shoot	Use	▪ No response.	▪ Include rifle with eyepiece camera mounted on weapon.	▪ Weapon selection option, reticle, and use of binoculars.	▪ Demilitarized weapon with realistic weight, balance, sight, etc.
	Add/Modify	▪ Include screen mounted on headset with peripheral vision.	▪ Indirect scanning/ firing capability but not IHAS.	▪ No response.	▪ Show where rounds are landing.
Commun-icate	Use	▪ No response.	▪ No response.	▪ No response.	▪ Headpiece.
	Add	▪ No response.	▪ No response.	▪ No response.	▪ No response.
Maintain Situational Awareness	Use	▪ Scanning technique.	▪ Indirect scanning/ firing capability with camera.	▪ Map and compass.	▪ Movement and visual capabilities.
	Add/Modify	▪ No response.	▪ Make more realistic – allow user to turn around and look behind him.	▪ Provide option to change view up and down.	▪ No response.
Data Base Specific	Use	▪ LBE.	▪ No response.	▪ No response.	▪ No response.
	Add	▪ No response.	▪ No response.	▪ No response.	▪ No response.

Maintain situational awareness. With regard to maintaining situational awareness, soldiers indicated that the prototype VIC should possess the indirect scanning firing capability with the camera as was done in VIC B. The soldier must also have the ability to turn around and look behind him (VIC B). Soldiers liked the movement and visual capabilities of VIC F, e.g., big screen view of objects, buildings. A system, which possessed a map and compass (VIC C), was also seen as highly desirable. In addition, soldiers mentioned the need to have an option to change the view from standing to prone (VIC C). Soldiers also mentioned the scanning capability provided by VIC A, with the screen mounted in the headset as a desirable feature to consider for future prototype systems.

Features to be Added to Improve Individual and Team Performance

Soldiers were also asked what additional features they would add to the prototype VIC to improve individual and group performance. Responses are presented in Table 12.

Move. To improve individual performance, soldiers indicated that the new VIC should be constructed such that the individual is unable to move through walls and ceilings (This is more of a data base problem, rather than a problem specific to a particular VIC). From a group performance perspective, it was difficult to coordinate team movement since each of the VICs moved differently and at variable speeds. In the future, this should not be a problem, since only one VIC system (but multiple VICs) will be used.

Shoot. From an individual perspective, future VICs would have weapon systems which require that the individual actually load and unload magazines to simulate the time it would take to reload in the real world. Soldiers also indicated that they would like to see the addition of laser aiming devices on weapons, and the capability to simulate the use of grenades. Soldiers felt that specific weapons used should be seen in the simulator, i.e., the SAW gunner should be using that weapon in the simulator. From a group perspective, soldiers indicated that they would like to add a sniper option.

Communicate. From an individual standpoint, the soldiers indicated they would like to see the addition of smoke, flares and the ability to use hand and arm signals included. From a group perspective, the use of smoke, flares, and arm and hand signals were also mentioned as desirable characteristics or features to include or play on the new VICs. Soldiers also suggested the use of throat mikes, but limiting communication primarily to the squad leader and team leaders.

Maintain situational awareness. To enhance situational awareness from an individual standpoint, soldiers suggested the inclusion of night vision goggles (NVGs), night sights, binoculars, and scopes. They also suggested the use of large screens, to include additional screens for above, below, and behind. The soldiers also recommended the inclusion of maps and a compass. Soldiers also recommended the use of improved audio/visual systems so that soldiers can accurately determine the direction of fire. From a team perspective, soldiers reiterated the need for binoculars, the screen set-up mentioned above, and improved audio/visual systems for identifying the direction of fire.

Miscellaneous. Some additional comments made by soldiers for enhancing individual performance in the new prototype VIC included the addition of night scenario capability, and the use of a more realistic weight load (load carrying equipment and armor/Kevlar vest). To enhance team performance in the new VIC, soldiers mentioned the need to improve the visuals. They preferred another means to differentiate team members without tagging them with labels on the screen. The also indicated that they would like to see included cover and/or body armor that would actually provide protection. Finally, soldiers indicated that they would like to have the ability to mark cleared rooms in MOUT.

Table 12

Features to Add to New VIC for Improving Individual and Team Performance

AREAS	To Improve Individual Performance:	To Improve Team Performance:
Move	▪ Prevent movement through walls/ceilings.	▪ Modify VICs so that they are all the same speed.
Shoot	▪ Add magazines for ammunition and simulate the time it would take to reload. ▪ Add laser aiming devices. ▪ Include grenades. ▪ Specific weapon used should be seen in simulator (e.g. the SAW gunner should be using that weapon in the simulator).	▪ Add sniper option. ▪ Include grenades.
Communicate	▪ Include smoke. ▪ Include flares and other signals. ▪ Add ability to use hand and arm signals. ▪ Use better audio equipment. ▪ Modify VICs so that they are not loud.	▪ Include smoke. ▪ Includes flares and other signals. ▪ Add ability to use hand and arm signals. ▪ Use throat mikes, so the equipment is not in the way. ▪ Limit radio communication to SL and TL. ▪ No communication between team members and TL -- team members may become too dependent on this type of intrateam communication.
Maintain Situational Awareness	▪ Add night vision goggles (NVGs). ▪ Add night sights. ▪ Include binoculars and scopes. ▪ Use large screens (like VIC F), include additional screens for above, below, and behind. ▪ Include real map and compass. ▪ Improve audio/visual systems so that users may better determine direction of fire.	▪ Include binoculars. ▪ Use three screens, with one on top to see overhead. ▪ Improve audio/visual systems so that users may better determine direction of fire.
Misc.	▪ Add night scenario capability. ▪ Use more realistic weight load (LCE and body armor/Kevlar).	▪ Enhance the visuals. ▪ Differentiate team members without tagging them. ▪ Increase consistency between VICs. ▪ Include cover and/or body armor to give actual protection. ▪ Include ability to mark cleared rooms in MOUT.

Improving the 29 Palms Data Base

Soldiers were also asked how the data bases could be improved. Their responses are summarized in the following sections.

Realism of the terrain. Soldiers indicated that the desert terrain needs to be more than just plain dirt. Vegetation, boulders, rocks, trenches, obstacles, and trees should be added.

Graphics. Graphics need to be more like the DISAF with hill crests instead of razor peaks. The sharp angles of hills and mountains are unrealistic and should be more rounded. Soldiers indicated that what they saw on the screen did not necessarily reflect what they saw on the computer screens during the AAR. Ravines, for example, could not be seen on the VIC systems but could be seen on the master computer.

Cover and concealment. The soldiers' major complaint was that there was no cover provided, e.g., hill crests, which made it impossible for them to practice individual movement techniques. No cover was offered unless the individual was in a dead space. The desert terrain, as portrayed in the data base, made it very difficult, if not impossible, to estimate distance. There was no depth perception. The soldiers indicated that improvements must be made to enable the soldier to more accurately detect dead space.

Enemy. Soldier responses indicated that the enemy was too well camouflaged. There was no indication of the opposing force (OPFOR) position, e.g., bunker, although with a small OPFOR element there might not be a bunker. But there were also no tracks of vehicles in the sand and no other indications that the enemy might be present, or if present, how they got there.

Navigation. Soldiers indicated that improvements were needed in the distinctiveness of the terrain when viewed from a distance. As it was, one hill top looked like the objective when many times it was not. Soldiers reported getting misoriented, particularly with no maps or compass.

Exercise specific. With the 29 Palms data base, as currently configured, the team always had the same start point. The enemy was always at the top of a hill and the team had to go far out of their way get to their objective. The soldiers indicated that they wanted more variety in their missions.

Improving the MOUT Data Base

Walls. Soldiers indicated that the walls should be solid. They felt that you should not be able to walk through walls or see through them.

Buildings. Soldier responses indicated that they would like to be able to go in to all buildings. Buildings, in the soldiers' opinion, should be made of different shapes and made more distinct. Doors should be put inside rooms. Soldiers also felt that furniture and fixtures should

also be added to the rooms. Walls and floors should also be different colors to allow the soldiers to better distinguish their location and allow them to better orient themselves in the buildings.

See. Soldiers indicated that it was important that everybody be able to see the same thing. Specifically, soldiers in their individual VICs and across VICs should see the same thing as the individuals operating the MOD SAF to ensure a "fair fight".

Environment. Soldiers indicated that they needed more things to maneuver around, e.g., cars, tanks, trees, obstacles, booby traps, wire obstacles, rubble; sewer systems; high weeds for concealment.

Civilians. There was also a need expressed to represent civilians on the battlefield so the soldiers could train on being able to distinguish the civilians from the OPFOR and not shoot indiscriminately.

Weapons. Soldiers also expressed a need to be able to use grenades and other dismounted infantry equipment.

Reactions to the McKenna MOUT Site

There were some important differences in how McKenna was perceived in the real world as opposed to the virtual world. Some of these impacted the fire team's approach to the objective. To the soldiers, the single three-story building at McKenna dominated the real site much more than it did in the virtual world. It made them more vulnerable to enemy fire than they expected. Consequently, they would have taken different approach routes, in order to lessen the degree to which they were exposed to the enemy. Movement to the objective would also have been slower, as they would have been alert for unexpected obstacles such as trip wires. Movement to the objective would have involved more individual movement techniques in the real world, as in the virtual world not all the buildings could be occupied by the enemy, and the soldiers had a false sense of security in the virtual world. In addition, the soldiers would have entered the MOUT site through the sewer system, if this capability had been possible with the simulation. Woods and depressions on one side of the site were not depicted in the data base. If they had been shown, these terrain features would have been used by the fire team.

The roads seemed wider in the real world than in the data base. On the other hand, the buildings seemed more spread out in the data base than the real world. The sewers were higher and bigger in the data base than the real world. The general terrain appeared flatter in the virtual than the real world.

The interior of the buildings also appeared somewhat different in the real world. Rooms seemed smaller than in the data base. The stairs were often darker than in the data base. One building had rooms with no windows, which made these rooms extremely dark; but they were fully lit in the virtual world. In addition, due to the outside light, shadows sometimes occurred, but shadows were not depicted in the virtual world. In the real world, soldiers often use shadows to detect other people and movement. Another difference was that soldiers were able to simply

walk into buildings in the virtual world, where as doors would have to be kicked in or knocked down in the real world.

Of particular interest was that the interior of one building was 180 degrees off in the virtual world's data base. One of the soldiers immediately noticed this; he knew that the stairs faced the wrong direction. None of the soldiers had been told of this error in the data base during the exercises. This critical incident shows that soldiers can learn the interior of buildings through incidental learning in a virtual environment. More important, it would appear that if soldiers used a virtual environment for mission rehearsal and were directed to learn the interior of buildings, they would be very successful in doing this.

Finally, after seeing the actual buildings, one squad leader indicated that he would have cleared them the same way on-site. In addition, he indicated that the virtual reality technology would be good for mission rehearsal.

Discussion

The primary focus of this research was to get the user community, i.e., infantry soldiers, actively involved in the evaluation process to determine how well the various VIC technologies met user needs. Specifically, the data collected during the User Exercises were to be used to help identify the strengths and weaknesses of the four VICs, and serve as a guide in the development of future generation VICs. All VICs had certain strengths and weaknesses. A key factor in considering the development of future generation VICs is the level of realism provided by the system. The overall theme running throughout this research was that the more realistic the action or equipment the more the soldiers liked the system, e.g., treadmill in VIC B; the demilitarized weapon used in VIC F. However, the way a system accomplished this realism was an important consideration. The comments on the restricted nature of the harness system and difficulty in controlling movements in VIC B, for example, indicated that while the system was liked as a whole, additional refinements or modifications are clearly needed. Moreover, additional thought must be given to the exact purpose of the VICs, e.g., mission rehearsal, to evaluate new equipment and its employment, to assess the feasibility of new techniques, tactics and procedures. A careful consideration of the purpose(s) served by these VICs would go a long way in shaping the requirements of future generation VICs.

Another overriding theme was system reliability. To be used effectively, the VICs must be reliable, and not subject to frequent recalibration as was the case for VIC A which was extremely frustrating to the soldiers. The following sections elaborate on these themes in addition to focusing on the interaction between the VICs and the data bases.

Overall Assessment of VICs

The soldiers' rankings of the VICs by tasks showed that VIC B was the preferred system. When the VICs were compared by tasks on each of four dimensions, a clear halo effect was observed. VIC B was viewed as the most flexible (in terms of being able to perform more aspects of various tasks); the easiest with regard to performing most tasks; the best in terms of enabling tasks to be performed in a tactically sound manner; and the most realistic. Moving in

general, and movement as a team member in the 29 Palms data base in particular, was difficult for the soldiers in VIC B. This was due, to a large extent to the greater physical (and more realistic) effort involved in moving in this VIC. Almost invariably, in the 29 Palms scenarios, the soldiers in VIC B ended up falling far behind the rest of the team because of the difficulty in moving, particularly going up hills as the treadmill resistance progressively increased to simulate walking up sloped terrain. After a while, the soldiers made adjustments by having VIC B take the lead in the 29 Palms scenarios to ensure all team members stayed together.

Subsequent data from the interview responses indicated a common factor, which seemed to explain the consistently high rankings given to VIC B across all dimensions. That factor was realism. Soldiers viewed VIC B as the most realistic, due in large part to the ODT, aiming features of the weapon, screen set up, and the ability to estimate distance and determine dead space. Statistical analyses of the average VIC rankings by task, collapsing over the four dimensions described above, did reveal a significant effect for VIC. However, as the post-hoc analyses showed, only the difference between VICs B and A were significant. The subjective responses, though, indicated clear preferences for selected aspects of the various systems.

Factors Influencing Soldiers' Ratings

Realism of task performance in VICs. All VICs were at least somewhat effective for engaging targets, simulating movement, and identifying objects and people. The responses from the Evaluation Questionnaire suggest that how these VICs accomplished these tasks was a crucial factor in determining individual preferences for a specific VIC or VICs. For the 29 Palms data base, movement over open, flat terrain and over hills and cross compartments, and firing and moving as a team member were most similar to real world performance of the same tasks in VIC B. VIC C, which involved no actual physical actions on the soldier's part to approximate movement, was a close second to VIC B in ratings. Soldier interview responses suggested several reasons for the high ratings for VIC C in these areas. While movement was not realistic in VIC C, in the sense that the soldier did not have to walk to make the computer icon walk, soldiers did appreciate the ease with which their icon could move by using the joystick. The clear visuals may have also been a contributing factor, since it made it very easy to identify personnel. As was noted earlier, while realism was a major factor influencing soldier ratings, ease of performing the task was another recurring factor mentioned by soldiers, which may have influenced their ratings to some degree.

Soldier ratings strongly indicated that weapon firing was most similar to the real world performance of this task in VIC F. Interview responses indicated that using a demilitarized weapon in VIC F and being able to realistically aim and manipulate this weapon were the major reasons VIC F received such high ratings in this area. Moreover, soldier responses from the Evaluation Questionnaire indicated that engaging targets in VIC F, particularly in the MOUT data base, took about the same time as it did in the real world; once again, emphasizing the realistic aspects of performing the task. Tasks that were time consuming to perform, difficult, or awkward appeared to contribute negatively to the soldier preferences for a specific VIC. The closer the task simulated by a VIC approximated real world performance in action, time, and effort (for the most part), the greater the preference for that VIC.

Tasks unable to be performed. Generally, there were fewer tasks that were unable to be performed than tasks that were difficult to perform (see Tables 3 and 4). More tasks were unable to be performed in the 29 Palms environment than in the MOUT environment. Visual recognition (specifically detecting enemy soldiers and estimating distance to other personnel), and weapon engagement (particularly detecting enemy fire) accounted for the majority of tasks that soldiers indicated they were unable to perform in the 29 Palms data base. The inability to perform these tasks was, with one exception, noted across all VICs. For the MOUT data base, the task most frequently noted by soldiers as unable to be performed was, again, detecting enemy fire (weapon engagement). Instances were observed across all VICs. The pattern of results obtained, suggest that the inability to perform the visual recognition and weapon engagement tasks noted above were less a problem with the VICs and more a problem with the data base.

Difficulty of performing tasks in VICs. As can be seen from Table 4, difficulty in performing tasks was, to a large extent, a function of the data base. Almost twice as many instances were noted by soldiers of tasks being difficult to perform (114) in the 29 Palms data base as opposed to performing tasks in the MOUT data base (58). The biggest problem appeared to be visual recognition tasks. Regardless of VIC, soldiers had difficulty performing these tasks. In sixty-four of 114 instances (in the 29 Palms data base), tasks rated as difficult to perform occurred in this area. Visual recognition tasks rated as most difficult, in order of difficulty, were: detect enemy soldiers, identify dead space, estimate distance to other personnel, determine activity of your team or enemy, and identify assigned sectors.

Tables 5 and 6 reinforce some of the findings noted above, namely the ability to detect or see the enemy was much more difficult to do in the 29 Palms environment than in the MOUT environment. The percentage of scenarios in which soldiers indicated that they saw the enemy ranged from 33% in VIC A to 54% in VIC F. In the MOUT environment, the percentages were much higher but the improvements were not seen across all VICs. For 90% of the scenarios in VICs B and 84% of the scenarios observed in VIC F, soldiers indicated that they could see the enemy. VIC A showed some improvement in detecting the enemy in 41% of the scenarios observed but VIC C detection rates decreased by approximately 50%. Soldiers were able to detect the enemy in only 21% of the scenarios that were observed. As was noted before, this decrease in detection rate was due primarily to technical limitations, that precluded soldiers from seeing or going inside of buildings in this VIC.

Difficulty of performing tasks, per se, was not the overriding factor in determining soldiers' preferences for a given system. For VIC B, movement was difficult from many respects; and shooting was difficult; however this VIC was the most preferred system. Summary comments show more of a parallel between the comments and ratings for VIC A. VIC A, probably the least preferred of all VICs, was poorly received. The summary comments indicate that difficulties in moving, shooting, communicating, maintaining situational awareness, and realism, the awkwardness of moving, and the poor reliability of the system, compared to the other VICs, were major reasons for the soldiers' poor ratings of VIC A.

VIC Training

Each VIC required training. None was engineered such that all actions could be executed as a soldier would perform them with tactical equipment in the field. To the extent that the actions required by a VIC are similar to what a soldier habitually does, less training on the system itself will be required. To the extent that required actions are unnatural or different than normal, then more training will be required.

In the User Exercises, there were indications that some soldiers were not fully trained on all aspects of every VIC even at the end of the exercises. For example, some still had some difficulty in maneuvering easily with the VIC B ODT; some had difficulties in moving efficiently and with confidence in VIC A. Others had trouble manipulating the VIC C levers in order to aim and fire quickly when the enemy was running, or to adjust the head separately from the body with the joystick, requiring some contractor assistance. Some did not always take advantage of the 10 ft space in VIC F during the MOUT exercises. Soldiers' training status was undoubtedly made more difficult by the fact that they had to learn four systems.

It is important that soldiers are trained fully on such systems prior to the start of any exercise. Simply executing exercises for "familiarization" or "warm-up" is insufficient training. In fact, there were instances where soldiers went through all the user exercises and failed to use certain capabilities of a VIC because they had not been thoroughly trained. Soldiers should also be trained on specific techniques for using a VIC that will facilitate their performance. If a soldier has not "mastered the VIC," then his attention will be focused on the VIC itself and not the mission. A formal test of VIC skills should be given prior to conducting exercises to identify any additional training required.

Impact on Individual and Fire Team Performance

Based on observations by the research staff, over time, the soldiers showed more skill and confidence in using the VICs. For example, they began to react immediately to the enemy situation or the terrain by going prone or taking a knee, although this was easier to do in some VICs than others (e.g., easier in VIC C than VIC A). The scanning and movement patterns in the VICs became more controlled and systematic. They also took advantage of some of the unique capabilities of each VIC. For example, they used the compass and map features in VIC C to assist in navigating in the 29 Palms data base; the self-picture to check on their position. The indirect view capability of VIC B was used effectively in clearing rooms. Some, but not all soldiers, worked primarily the VIC A box during MOUT scenarios in order to control movement speed and direction effectively.

The exercises also demonstrated that soldiers could learn the interior of buildings. This was evident in team leader's instructions for clearing a building and in the team members' ability to execute as directed. It was also evident in the visit to the McKenna MOUT site where one of the soldiers correctly determined, without assistance, that the actual floor plan of one building did not match that in the virtual world. This finding is consistent with earlier research that examined the transfer of spatial information acquired in virtual environments to real world situations (Witmer, Bailey, & Knerr, 1995).

With time, the soldiers also began to work as a team; e.g., bounding, assignment of responsibilities to different team members, continually assessing the location of the other team members. Sometimes team leader decisions regarding team member roles seemed to be based on the individual, sometimes a unique feature of a VIC, and sometimes both. They were able to pass each other in a hallway without bumping into each other. They communicated better at the end than at the start of the exercises. Soldiers in other VICs adapted to the real-time movement of VIC B in terms of the order of march and other team movement. The indirect view capability of VIC B was used effectively by the squad leader in directing the actions of the fire team members.

Despite these positive factors, there remained some indications of lack of teamwork, e.g., moving directly to a team member's front when bounding, being unaware of time-distance factors, some fratricides. Furthermore, some soldiers felt that the systems, as configured, did not help them in determining how to do things in the real world; that they were simply demonstrating what the systems could do. In some instances, they did not and could not execute missions in a tactically correct manner.

Constructing the Ideal VIC

Based on the user exercises, soldier responses, and our observations, the following suggestions are made regarding how the VICs could be improved, from a functional point-of-view. These suggestions center on soldier and fire team skills.

The ideal VIC should have two movement modes: real-time and automatic. If time-distance factors are key factors in the exercises of interest, then real-time movement should be a feature. Movement (walking/running) in the VIC should require a soldier to exert the effort and force he would exert in the real world. However, this movement should not be constrained in unnatural ways, nor should movement be executed within a VIC in a way that conflicts greatly with habitual ways of moving. In addition, soldiers should be able to control the speed of their movement. Being put on "auto-pilot" is detrimental in such situations. However, for some training and research purposes, e.g., mission rehearsal and planning, automatic movement capability may be desirable.

When possible, the soldier's actual position in the VIC should correspond to his position in the virtual world (kneeling in the VIC should be kneeling in the virtual world). However, when this is not possible, the VIC needs to provide immediate, and easily discernable feedback regarding the virtual world position. For example, if the visual scene is lowered to represent a prone position, then the change in scene should be easily detectable by the soldier.

The weapon should replicate a real weapon in terms of weight, balance, design, and feel. Soldiers did not like a plastic toy. In addition, ideally each soldier should have his assigned weapon, e.g., M16A2 rifle, SAW, M203. The firing simulation should be accurate. Much face validity to a system is lost when a soldier fires 20 times at close range, and the enemy does not fall to the ground. The firing simulation should also replicate the weapon's capability, e.g., single round vs multiple-round bursts. Soldier load should be simulated; magazine changes required. The impact of weapon rounds should be displayed.

An ideal VIC should also have the capability for a soldier to pick-up another weapon if demanded by the mission. When a buddy, who has a more powerful weapon such as the SAW, goes down, the soldier should be able to take the SAW as his own weapon. In turn, the soldier should then immediately see that he has a new weapon, the SAW instead of the M16 rifle. The ideal VIC should also simulate other soldier equipment such as flares, grenades, binoculars, and smoke.

The means of communication, both auditory and non-auditory, should be modified to reflect how soldiers communicate in the field. In the exercises, when one soldier spoke, all fire team members heard him. The VICs should be modified to allow one-on-one communication and military radio communication as well. During training, soldiers eventually adapted to the inability of the systems to display hand-and-arm signals. But the ideal VIC should have hand-and-arm signal capability. The soldiers indicated that they communicated verbally more than they would have in the field. In addition, some mentioned developing bad habits of talking and not using radio net procedures in accordance with unit standing operating procedures. The integration of hand-and-arm signals, and simulation of a military radio would improve VIC communication. Lastly, any noise generated by the VIC itself should not interfere with the communication process among team members.

Soldier reactions on the battlefield depend highly on what they see, making the visual system within each VIC extremely important. None of the VICs portrayed the real world with 100 percent fidelity. And, it was impossible to determine the relative impacts of the degree of resolution in each VIC from the resolution available in the data base from the interaction between these two sources of visual input. Nonetheless, soldier reactions regarding the difficulty in performing visual recognition tasks indicate the need to improve the visual display within the VIC. Higher fidelity displays are needed, and perceptual distortions should be minimized.

The portrayal of terrain features is critical to how fire teams are deployed. Soldiers need to be able to discern cover or concealment when bounding and executing individual movement techniques. Such features as tall grass, depressions, water, and shrubs are important. This type of terrain feature was missing in the soldiers' view of the 29 Palms data base, making it impossible, for example, for soldiers to determine if they were bounding to an area where they were concealed. Sand dunes looked like Egyptian pyramids with no place to hide on the slope. Soldiers must be able to estimate range, determine dead space, and discriminate enemy from friendly forces. The soldiers' inability to detect enemy firing may have been a joint function of the visual display and their inability to localize the direction of fire. Distances on the 29 Palms data base were also distorted; they appeared to be much greater than they actually were. In one instance, the enemy was only 134 meters away, but they appear as specks on the horizon. The visit to the McKenna MOUT site reflected another type of distortion, which probably resulted from an interaction between height and depth perception. This was most obvious in the soldiers' reaction to the dominant position of the three-story building on the site itself, which was not perceived in any of the VICs. If they had been at the actual site, they would have modified how they executed their approach to the objective. If VICs are to be used for mission rehearsal, then such perceptual distortions must be minimized.

An ideal VIC should allow soldiers to scan in three-dimensions as they would in the real world and at a speed similar to that in the real world. For example, the ability to "glance over one's shoulder," to check on your position or the situation in general, is a needed feature. This was not possible with some VIC technologies. Incorporation of some type of head mounted display with peripheral vision was one possible alternative suggested for modifying the scanning capability of the new VIC. This would also help improve situational awareness as would the inclusion of a map and compass.

An improved VIC should depict the unique sounds of different weapon systems, as well as the direction from which the firing is occurring. These features are critical to dismounted soldier operations. Part of situational awareness on the battlefield is the soldier's ability to discriminate enemy from friendly fire, and the sounds of different friendly weapons (M16 rifle vs a SAW vs a M60 machine gun). None of the VICs adequately simulated audio sounds on the battlefield. Differences in weapon systems could not be distinguished nor could soldiers localize the direction of fire.

The VIC technology should be flexible in that it must be able to adapt to additions or changes to the soldier's warfighting ensemble. The capability for rapid prototyping must exist. Some of the VICs included advanced capabilities, e.g., global positioning system, indirect view for target acquisition, which were used to great effect by fire team members.

Enhanced interactivity between a VIC and the environment is needed in some cases. This interactivity may require "dynamic" terrain. For example, in MOUT, soldiers need to be able to mark the rooms that have been cleared; they need to be able to knock down doors. In addition, the VIC technology for MOUT situations should prevent soldiers from falling through the stairs and getting stuck in walls.

An ideal VIC should not require tags or labels on soldiers in order to differentiate them. Actual soldier size, the weapon carried, and other distinguishing features should be portrayed.

The Total System

The effectiveness of any virtual simulation using VIC technology also depends on the adequacy of the data base and the SAF, both enemy and friendly. The total system must be considered. Inadequacies in the two data bases have already been mentioned. When using these simulations for either research and development or for training purposes, some of these data base weaknesses could lead to inappropriate training/mission rehearsal or erroneous conclusions. Additionally, rules of engagement should correspond to the real world, e.g., a hit should not always mean a kill. There must be some assurance of a "fair fight" with the opposing force. For instance, the opposing force should not be "all-knowing" nor "all-seeing," when the VIC unit cannot be. The terrain data base used by the enemy should be the same as that used by the VICs. Making these system-wide enhancements presents additional challenges.

Generalizability of Findings

In addition to being a small sample, the soldiers used in the User Exercises were not MOS 11B, Infantry. As 11M, their primary focus has been the Bradley Fighting Vehicle, rather than on dismounted 11B skills. In addition, they had only limited experience as team leaders or as team members. How this lack of experience may have affected VIC ratings and the evaluation as a whole is unclear. However, it would be instructive to compare the responses from experienced (e.g., from the Ranger Battalion) infantry soldiers who have served as both team members and as team leaders with the responses obtained from the present sample.

It also would have been interesting to get these experienced infantry soldiers' opinions from the perspective of the specific purpose(s) to be served by these VICs. For example, if the purpose of these VICs is mission rehearsal, how important is it that all actions be simulated in the VIC exactly the same way as the individual would perform them in the real world? Soldier ratings of these VICs were based, it seems, more from the perspective of systems for training individual soldier skills. In this instance, the realism factor makes sense. But is this really the best use of this technology for the infantry soldier? It may be that several VIC systems are needed; a system requiring realistic soldier actions and a more synthetic system such as VIC C for mission rehearsal and planning. These issues will have to be addressed in the next set of User Exercises to ensure that the future generation VIC system(s) provide the maximum training value to the infantry soldier.

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APPENDIX A
VIC Capability Assessment Questionnaire

Name: _____		Date: _____		Time: _____
Position: Tm Ldr	SAW	Rifleman 1	Rifleman 2	
VIC:	A (Sensor)	B (Tread)	C (Computer)	F(Foot)
Scenario: MOUT	29 Palms			

Using the scale below, rate how difficult it was for you to perform the following tasks.

1 = No opportunity to perform **2 = Unable to perform**
3 = Could perform easily **4 = Could perform with difficulty**

Movement

1. _____ Move around and inside of buildings.
2. _____ Enter door, window, hole.
3. _____ Move over open, flat terrain.
4. _____ Move over hills and cross compartments.
5. _____ Move tactically

Orientation (of Self and Others)

6. _____ Move through a building knowing which rooms were cleared.
7. _____ Determine where team members are around and inside of buildings.
8. _____ Determine own movement direction.
9. _____ Maintain position relative to other personnel.
10. _____ Determine where team members are in open, flat terrain.
11. _____ Determine where team members are over hills and cross compartments.

Communication

12. _____ Identify hand and arm signals.

Visual Recognition (Person, Target, Object)

13. _____ Estimate distance to other personnel.
14. _____ Locate your fire team members.
15. _____ Determine activity (e.g., firing, kneeling, running) of your team or enemy.
16. _____ Identify specific fire team members.
17. _____ Identify assigned sectors.
18. _____ Identify dead space.
19. _____ Detect enemy soldiers.

Weapon Engagement

20. _____ Aim your weapon.
21. _____ Fire your weapon.
22. _____ Detect enemy fire.
23. _____ Fire from tactical positions

APPENDIX B
VIC Evaluation Questionnaire

Name: _____		Date: _____		Time: _____
VIC:	A (Sensor)	B (Tread)	C (Computer)	F (Foot)

Rate the following dimensions, from 1 to 5, based on your **overall assessment** of the capabilities of the VIC you were just assigned to. **For questions 1-3 use the following scale:**

1 = Very effective **2 = Generally effective** **3 = Somewhat effective**
4 = Generally ineffective **5 = Very ineffective**

1. _____ How effective was this VIC for engaging targets?

2. _____ How effective was this VIC for simulating movement?

3. _____ How effective was this VIC for identifying objects, people, etc.?

For questions 4-7 use the following scale:
1 = Yes, very similar 2 = Somewhat similar 3 = No very dissimilar

4. _____ Does this VIC allow you to move over open, flat terrain in a manner similar to how you would move in the real world ?

5. _____ Does this VIC allow you to move over hills and cross compartments in a manner similar to how you would move in the real world ?

6. _____ Does this VIC allow you to move around and inside of buildings in a manner similar to how you would move in the real world ?

7. _____ Does this VIC allow you to fire your weapon in a manner similar to how you would do it in the real world?

8. _____ Does this VIC allow you to fire and move as a team member in a manner similar to how you would fire and move in the real world?

For questions 9-10, check the response which best applies

9. Could you engage targets as quickly on this VIC as on a real weapon?
_____ Quicker than a real weapon
_____ Slower than a real weapon
_____ About the same as a real weapon

10. Could you recognize people, objects, and targets as quickly on this VIC as you could in the real world?
_____ Quicker than in the real world
_____ Slower than the real world
_____ About the same as in the real world

APPENDIX C
VIC Comparison Questionnaire

Name: _____	Date: _____	Time: _____

1. Rank order the VICs, from 1 to 4, based on how **MANY ELEMENTS OR ASPECTS** of the following tasks and skills can be performed.

1 = Best (More elements or aspects can be performed with this VIC than with any other)
4 = Worst (Fewer elements or aspects can be performed with this VIC than with any other)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as a member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

2. Rank order the VICs, from 1 to 4, based on how **EASY** it is to perform the following tasks and skills.

1 = Best (Can be performed most easily)
4 = Worst (Hardest to perform)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

3. Rank order the VICs, from 1 to 4, based on how well each allows you to perform the following tasks or skills in a **TACTICALLY SOUND** manner.

1 = Best (No differences or the fewest differences from tactical procedures)
4 = Worst (Performance differs the most from tactical procedures)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

4. Rank order the VICs, from 1 to 4, based on how well each allows you to perform the following tasks and skills **LIKE YOU WOULD PERFORM THE TASKS IN THE REAL WORLD**.

1 = Best (Most similar to real-world performance)
4 = Worst (Least similar to real-world performance)

	VIC A	VIC B	VIC C	VIC F
Move as an individual				
Move as member of a fire team				
Maintain situational awareness: Of your location, your fire team's location, the enemy situation, etc.				
Communicate				
Recognize people, targets, and objects				
Engage targets as an individual				
Engage targets as member of a fire team				
Control fires (as a team leader)				
Control movement (as a team leader)				

5. Rank order the VICs, from 1 to 4, based on how effective you feel each VIC would be at simulating the following positions.

1 = Best (Most effective for this position)
4 = Worst (Least effective for this position)

	VIC A	VIC B	VIC C	VIC F
Team leader				
SAW gunner				
Rifleman				
Squad leader				
Platoon leader				

APPENDIX D
VIC Observation Form

Name: _____			Date: _____	Time: _____
Position: Tm Ldr		SAW	Rifleman 1	Rifleman 2
VIC:	A (Sensor)	B (Tread)	C (Computer)	F (Foot)
Scenario: MOUT		29 Palms		

Circle which positions were used to move:

Walk Run Crawl

Circle which positions were used in firing:

Stand unsupported Kneel Prone Other _____

Speed of Movement:

Scanning:

Enemy Contact:

Did you see the enemy? _____Yes _____No

Did you see the enemy firing? _____Yes _____No

Did you fire at the enemy? _____Yes _____No

Were you killed? _____Yes _____No

What position were you in when you were killed?

_____Standing _____Kneeling _____Prone

If not killed, what was your final position?

_____Standing _____Kneeling _____Prone

APPENDIX E
Mean Task Rankings by VIC for Each Dimension for the VIC Comparison Questionnaire

Table E-1

Mean Task Rankings by VIC Based on How Many Elements or Aspects of Tasks Could be Performed - 29 Palms

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	3.25	.89	1.75	1.16	2.75	.89	2.25	1.16
Move as member of a fire team.	3.50	.63	1.88	1.13	2.50	.76	2.13	1.13
Maintain situational awareness.	3.13	1.13	1.63	.74	3.00	1.07	2.25	1.04
Recognize people, targets, and objects.	3.38	.92	2.00	1.07	2.50	1.20	2.13	.99
Engage targets as an individual.	3.75	.46	1.50	.53	2.13	.83	2.63	1.19
Engage targets as a member of a fire team.	3.50	.76	1.75	1.04	2.00	.76	2.75	1.16
Control fires (as a team leader).	3.50	.71	2.50	.71	3.00	1.41	1.00	0.00
Control movement (as a team leader).	2.00	1.41	2.00	0.00	3.50	.71	2.50	2.12

Note. For all tables in Appendix E, 1 = Best, 4 = Worst. Only the team leaders, n = 2, ranked the VICs with regard to controlling fires and movement.

Table E-2

Mean Task Rankings by VIC Based on Ease of Performing Tasks - 29 Palms

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	3.38	.74	2.75	1.16	1.75	1.16	2.13	.83
Move as member of a fire team.	2.88	.64	3.13	.99	1.75	1.16	2.25	1.28
Maintain situational awareness.	3.63	.52	1.38	.52	2.75	1.16	2.25	.89
Recognize people, targets, and objects.	3.38	.74	1.88	1.36	2.13	.64	2.63	1.19
Engage targets as an individual.	3.63	.52	1.38	.52	2.50	.93	2.50	1.20
Engage targets as a member of a fire team.	3.50	.76	1.50	.76	2.50	.93	2.50	1.20
Control fires (as a team leader).	3.00	0.00	3.00	1.41	3.00	1.41	1.00	0.00
Control movement (as a team leader).	3.00	0.00	3.00	1.41	3.00	1.41	1.00	0.00

Table E-3

Mean Task Rankings by VIC Based on Tactical Soundness of Performing Tasks - 29 Palms

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	3.25	.89	2.00	1.07	2.00	1.07	2.75	1.16
Move as member of a fire team.	3.38	.92	1.88	.99	2.50	1.07	2.25	1.16
Maintain situational awareness.	3.50	.76	1.63	.92	2.38	.92	2.50	1.20
Recognize people, targets, and objects.	3.38	.74	1.75	1.04	2.00	.76	2.88	1.25
Engage targets as an individual.	3.38	.74	1.50	.76	2.38	.92	2.75	1.28
Engage targets as a member of a fire team.	3.25	.71	1.63	.74	2.13	.99	3.00	1.31
Control fires (as a team leader).	4.00	0.00	1.50	.71	3.00	0.00	1.50	.71
Control movement (as a team leader).	4.00	0.00	1.00	0.00	3.00	0.00	2.00	0.00

Table E-4

Mean Task Rankings by VIC Based on Realistic Manner of Task Performance - 29 Palms

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	2.63	1.06	1.38	.74	3.00	.93	3.00	1.07
Move as member of a fire team.	2.75	1.16	1.63	1.06	3.00	.76	2.63	1.19
Maintain situational awareness.	2.88	.99	1.63	.92	3.25	.89	2.25	1.16
Recognize people, targets, and objects.	3.00	1.20	2.13	2.13	2.63	.92	2.25	1.16
Engage targets as an individual.	2.38	1.19	1.88	1.88	3.38	.74	2.38	1.30
Engage targets as a member of a fire team.	2.75	1.16	1.75	1.75	3.13	.83	2.38	1.30
Control fires (as a team leader).	3.00	0.00	1.50	.71	4.00	0.00	1.50	.71
Control movement (as a team leader).	3.50	.71	1.50	.71	3.50	.71	1.50	.71

Table E-5

Mean Task Ratings by VIC Based on How Many Elements or Aspects of Tasks Could be Performed - MOUT

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	3.00	.76	1.50	1.07	3.00	.93	2.50	1.20
Move as member of a fire team.	2.88	.83	1.50	1.07	3.13	.83	2.50	1.20
Maintain situational awareness.	3.00	1.07	1.50	.76	3.13	.83	2.38	1.19
Recognize people, targets, and objects.	2.88	1.13	2.00	1.07	2.88	.99	2.25	1.28
Engage targets as an individual.	2.71	1.28	1.88	1.13	2.63	.74	2.75	1.28
Engage targets as a member of a fire team.	2.63	1.30	1.75	1.04	3.00	.76	2.63	1.19
Control fires (as a team leader).	3.00	0.00	3.00	1.41	3.00	1.41	1.00	0.00
Control movement (as a team leader).	3.00	0.00	3.00	1.41	3.00	1.41	1.00	0.00

Table E-6

Mean Task Rankings by VIC Based on Ease of Performance of Tasks - MOUT

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	3.13	.64	2.88	1.25	2.00	1.07	2.00	1.20
Move as member of a fire team.	2.88	.64	2.50	1.31	2.50	1.31	2.13	1.25
Maintain situational awareness.	2.75	1.16	1.50	.76	3.25	.89	2.50	1.07
Recognize people, targets, and objects.	2.75	1.04	2.00	1.07	2.87	.83	2.38	1.51
Engage targets as an individual.	3.00	1.20	1.75	1.04	2.75	1.04	2.50	1.07
Engage targets as a member of a fire team.	3.00	1.20	1.75	1.04	2.75	1.04	2.50	1.07
Control fires (as a team leader).	3.50	.71	1.50	.71	3.00	1.41	2.00	1.41
Control movement (as a team leader).	3.50	.71	1.50	.71	3.00	1.41	2.00	1.40

Table E-7

Mean Task Rankings by VIC Based on Tactical Soundness of Performing Task – MOUT

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	2.88	.99	2.13	.99	2.50	1.31	2.50	1.31
Move as member of a fire team.	3.13	.64	2.00	1.07	2.50	1.31	2.38	1.30
Maintain situational awareness.	3.13	.83	1.50	1.07	3.00	.93	2.38	1.06
Recognize people, targets, and objects.	3.13	.99	1.63	1.06	2.88	.99	2.38	1.06
Engage targets as an individual.	2.88	.83	1.88	1.13	2.75	1.04	2.50	1.41
Engage targets as a member of a fire team.	3.00	1.07	1.88	.99	2.63	.92	2.50	1.41
Control fires (as a team leader).	3.50	.71	1.50	.71	3.50	.71	1.50	.71
Control movement (as a team leader).	3.50	.71	1.50	.71	3.50	.71	1.50	.71

Table E-8

Mean Task Rankings by VIC Based on Realistic Manner of Task Performance - MOUT

TASK	VIC A		VIC B		VIC C		VIC F	
	X	SD	X	SD	X	SD	X	SD
Move as an individual.	2.63	.92	1.75	1.04	3.13	1.25	2.50	1.07
Move as member of a fire team.	2.50	.93	1.88	1.13	3.00	1.20	2.63	1.19
Maintain situational awareness.	2.88	.83	1.50	.76	3.13	1.25	2.50	1.07
Recognize people, targets, and objects.	2.63	1.06	1.75	1.04	3.25	.71	2.38	1.30
Engage targets as an individual.	2.50	.76	2.25	1.16	3.00	1.07	2.25	1.49
Engage targets as a member of a fire team.	3.25	.71	1.88	.99	2.50	1.20	2.25	1.39
Control fires (as a team leader).	3.50	.71	1.50	.71	3.50	.71	1.50	.71
Control movement (as a team leader).	3.50	.71	1.50	.71	3.50	.71	1.50	.71

APPENDIX F
Effectiveness, Similarity, and Quickness Ratings by VIC and by Item for the VIC Evaluation Questionnaire

Table F-1

Effectiveness Ratings by VIC for Engaging Targets - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	0	37	37	20
Generally effective	57	62	62	40
Somewhat effective	43	0	0	0
Generally ineffective	0	0	0	20
Very ineffective	0	0	0	20

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 5 for VIC F.

Table F-2

Effectiveness Ratings by VIC for Simulating Movement - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	0	12	37	33
Generally effective	43	75	50	33
Somewhat effective	29	12	0	33
Generally ineffective	29	0	12	0
Very ineffective	0	0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table F-3

Effectiveness Ratings by VIC for Identifying Objects, People, etc. - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	0	37	37	50
Generally effective	71	62	50	17
Somewhat effective	29	0	12	17
Generally ineffective	0	0	0	0
Very ineffective	0	0	0	17

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table F-4

Similarity of Moving over Open, Flat Terrain in VIC to Real World Performance - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	0	29	29	17
Somewhat similar	57	71	57	67
Very Dissimilar	43	0	14	17

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Table F-5

Similarity of Moving over Hills and Cross Compartments in VIC to Real World Performance - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	0	14	29	17
Somewhat similar	57	86	57	67
Very Dissimilar	43	0	14	17

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Table F-6

Similarity of Firing Weapon in VIC to Real World Performance - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	29	0	14	83
Somewhat similar	29	71	43	0
Very Dissimilar	43	29	43	17

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Table F-7

Similarity of Firing and Moving as a Team Member in VIC to Real World Performance - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	14	29	29	17
Somewhat similar	43	71	71	67
Very Dissimilar	43	0	0	17

Note. n = 7 for VICs A, B, and C; n = 6 for VIC F.

Table F-8

Quickness of Engaging Targets in VIC Compared to Using a Real Weapon - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than a real weapon	0	29	25	0
Slower than a real weapon	100	57	62	17
About the same as a real weapon	0	14	12	83

Note. n = 7 for VICs A and B; n = 8 for VIC C; n = 6 for VIC F.

Table F-9

Quickness in Recognizing People, Objects and Targets in VIC Compared to Real World - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than a real weapon	0	14	0	0
Slower than a real weapon	86	57	37	50
About the same as a real weapon	14	29	62	50

Note. n = 7 for VICs A and B; n = 8 for VIC C; n = 6 for VIC F.

Table F-10

Effectiveness Ratings by VIC for Engaging Targets - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	17	17	60	40
Generally effective	50	33	40	40
Somewhat effective	33	33	0	20
Generally ineffective	0	17	0	0
Very ineffective	0	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table F-11

Effectiveness Ratings by VIC for Simulating Movement - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	17	17	0	20
Generally effective	33	67	60	20
Somewhat effective	50	0	40	60
Generally ineffective	0	0	0	0
Very ineffective	0	17	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table F-12

Effectiveness Ratings by VIC for Identifying Objects, People, etc. - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very effective	33	50	40	80
Generally effective	67	33	40	20
Somewhat effective	0	0	0	0
Generally ineffective	0	17	20	0
Very ineffective	0	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table F-13

Similarity of Moving Around and Inside of Buildings in VIC to Real World Performance - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	17	17	0	20
Somewhat similar	50	67	33	80
Very Dissimilar	33	17	67	0

Note. n = 6 for VICs A and B; n = 3 for VIC C; and n = 5 for VIC F.

Table F-14

Similarity of Firing Weapon in VIC to Real World Performance - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	33	17	0	80
Somewhat similar	33	50	25	20
Very Dissimilar	33	33	75	0

Note. n = 6 for VICs A and B; n = 4 for VIC C; n = 5 for VIC F.

Table F-15

Similarity of Firing and Moving as a Team Member in VIC to Real World Performance - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Very similar	17	50	0	40
Somewhat similar	67	50	75	60
Very Dissimilar	17	0	25	0

Note. n = 6 for VICs A and B; n = 4 for VIC C; n = 5 for VIC F.

Table F-16

Quickness of Engaging Targets in VIC Compared to Using a Real Weapon – MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than a real weapon	17	0	20	0
Slower than a real weapon	67	67	80	20
About the same as a real weapon	17	33	0	80

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table F-17

Quickness in Recognizing People, Objects and Targets in VIC Compared to Real World - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
Quicker than a real weapon	17	17	0	0
Slower than a real weapon	50	17	80	20
About the same as a real weapon	33	67	20	80

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

APPENDIX G
Task Difficulty Ratings by VIC and by Item for the VIC Capability Assessment Questionnaire

Table G-1

Task Difficulty Ratings by VIC for "Move over open, flat terrain"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	86	88	100	100
Could perform with difficulty	14	12	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-2

Task Difficulty Ratings by VIC for "Move over hills and cross compartments"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	12	0
Unable to perform	0	0	0	0
Could perform easily	100	75	87	100
Could perform with difficulty	0	25	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-3

Task Difficulty Ratings by VIC for "Move tactically"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	12	0
Unable to perform	14	0	0	0
Could perform easily	57	62	75	83
Could perform with difficulty	29	37	12	17

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-4

Task Difficulty Ratings by VIC for "Determine own movement direction"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	17
Could perform easily	71	62	100	83
Could perform with difficulty	29	37	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-5

Task Difficulty Ratings by VIC for "Maintain position relative to other personnel" - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	71	62	87	67
Could perform with difficulty	29	37	12	33

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-6

Task Difficulty Ratings by VIC for "Determine where team members are in open, flat terrain"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	12	0	17
Could perform easily	86	75	100	83
Could perform with difficulty	14	12	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-7

Task Difficulty Ratings by VIC for "Determine where team members are over hills and cross compartments"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	25	0	17
Could perform easily	71	62	87	67
Could perform with difficulty	29	12	12	17

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-8

Task Difficulty Ratings by VIC for "Estimate distance to other personnel"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	29	12	0	17
Could perform easily	43	62	50	33
Could perform with difficulty	29	25	50	50

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-9

Task Difficulty Ratings by VIC for "Locate your fire team members"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	17
Could perform easily	86	75	100	83
Could perform with difficulty	14	25	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-10

Task Difficulty Ratings by VIC for "Determine activity of your team or enemy" - 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	14	0	0	0
Could perform easily	71	50	75	67
Could perform with difficulty	14	50	25	33

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-11

Task Difficulty Ratings by VIC for "Identify specific fire team members"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	17
Could perform easily	100	100	100	83
Could perform with difficulty	0	0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-12

Task Difficulty Ratings by VIC for "Identify assigned sectors"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	29	12	25	33
Unable to perform	0	12	0	17
Could perform easily	43	37	25	50
Could perform with difficulty	29	37	50	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-13

Task Difficulty Ratings by VIC for "Identify dead space"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	29	12	12	17
Unable to perform	0	12	25	0
Could perform easily	29	37	25	0
Could perform with difficulty	43	37	37	83

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-14

Task Difficulty Ratings by VIC for "Detect enemy soldiers"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	17
Unable to perform	14	25	25	17
Could perform easily	0	25	25	0
Could perform with difficulty	86	50	50	67

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-15

Task Difficulty Ratings by VIC for "Aim your weapon"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	17
Could perform easily	57	87	87	83
Could perform with difficulty	43	12	12	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-16

Task Difficulty Ratings by VIC for "Fire your weapon"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	17
Unable to perform	0	0	0	16
Could perform easily	100	100	100	67
Could perform with difficulty	0	0	0	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-17

Task Difficulty Ratings by VIC for "Detect enemy fire"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	14	0	12	17
Unable to perform	29	62	12	50
Could perform easily	29	12	25	33
Could perform with difficulty	29	25	50	0

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-18

Task Difficulty Ratings by VIC for "Fire from tactical positions"- 29 Palms (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	29	0	0	17
Unable to perform	0	0	0	33
Could perform easily	57	75	87	17
Could perform with difficulty	14	25	12	33

Note. n = 7 for VIC A; n = 8 for VICs B and C; n = 6 for VIC F.

Table G-19

Task Difficulty Ratings by VIC for "Move around and inside of buildings"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20	0
Unable to perform	0	17	60	0
Could perform easily	83	50	0	100
Could perform with difficulty	17	33	20	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-20

Task Difficulty Ratings by VIC for "Enter door, window, hole"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20	0
Unable to perform	0	33	60	0
Could perform easily	83	67	0	100
Could perform with difficulty	17	0	20	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-21

Task Difficulty Ratings by VIC for "Move tactically"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	67	83	80	100
Could perform with difficulty	33	17	20	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-22

Task Difficulty Ratings by VIC for "Move through a building knowing which rooms were cleared"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	33	20	0
Unable to perform	0	0	40	0
Could perform easily	50	67	0	80
Could perform with difficulty	50	0	40	20

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-23

Task Difficulty Ratings by VIC for "Determine where team members are around and inside of buildings"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	40	0
Could perform easily	83	83	0	100
Could perform with difficulty	17	17	60	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-24

Task Difficulty Ratings by VIC for "Determine own movement direction"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	100	83	100	100
Could perform with difficulty	0	17	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-25

Task Difficulty Ratings by VIC for "Maintain position relative to other personnel" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	83	83	100	100
Could perform with difficulty	17	17	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-26

Task Difficulty Ratings by VIC for "Estimate distance to other personnel"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	20
Could perform easily	67	83	80	60
Could perform with difficulty	33	17	20	20

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-27

Task Difficulty Ratings by VIC for "Locate your fire team members" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	83	100	100	100
Could perform with difficulty	17	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-28

Task Difficulty Ratings by VIC for "Determine activity of your team or enemy" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	20	0
Could perform easily	83	83	80	80
Could perform with difficulty	17	17	0	20

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-29

Task Difficulty Ratings by VIC for "Identify specific fire team members" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	0	0
Unable to perform	0	0	0	0
Could perform easily	83	100	80	100
Could perform with difficulty	17	0	20	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-30

Task Difficulty Ratings by VIC for "Identify assigned sectors" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	17	0	40	20
Unable to perform	17	17	0	20
Could perform easily	50	83	60	60
Could perform with difficulty	17	0	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-31

Task Difficulty Ratings by VIC for "Identify dead space" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	33	17	40	20
Unable to perform	17	17	0	0
Could perform easily	50	67	20	60
Could perform with difficulty	0	0	40	20

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-32

Task Difficulty Ratings by VIC for "Detect enemy soldiers" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20	0
Unable to perform	17	0	20	0
Could perform easily	50	67	0	100
Could perform with difficulty	33	33	60	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-33

Task Difficulty Ratings by VIC for "Aim your weapon" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	0	0	20	0
Unable to perform	0	0	20	0
Could perform easily	67	67	40	100
Could perform with difficulty	33	33	20	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-34

Task Difficulty Ratings by VIC for "Fire your weapon" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	17	0	40	0
Unable to perform	0	0	0	20
Could perform easily	83	100	60	60
Could perform with difficulty	0	0	0	20

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-35

Task Difficulty Ratings by VIC for "Detect enemy fire"- MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	17	0	40	20
Unable to perform	50	33	20	20
Could perform easily	17	50	40	60
Could perform with difficulty	17	17	0	0

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Table G-36

Task Difficulty Ratings by VIC for "Fire from tactical positions" - MOUT (in percent)

	VIC A	VIC B	VIC C	VIC F
No opportunity to perform	50	0	20	0
Unable to perform	0	0	0	0
Could perform easily	50	83	60	60
Could perform with difficulty	0	17	20	40

Note. n = 6 for VICs A and B; n = 5 for VICs C and F.

Tasks Unable to be Performed or Performed with Difficulty - Frequency of Occurrence by Task Category, VIC, and Data Base

Table G-37

Tasks Unable to be Performed by Soldiers Across VICs – 29 Palms

TASK	VIC				Total Responses
	A	B	C	F	
MOVEMENT	**1**	**0**	**0**	**0**	**1**
• Move over open, flat terrain.	0	0	0	0	0
• Move over hills and cross compartments.	0	0	0	0	0
• Move tactically.	1	0	0	0	1
ORIENTATION	**0**	**3**	**0**	**3**	**6**
• Determine own movement direction.	0	0	0	1	1
• Maintain position relative to other personnel.	0	0	0	0	0
• Determine where team members are in open, flat terrain.	0	1	0	1	2
• Determine where team members are over hills and cross compartments.	0	2	0	1	3
VISUAL RECOGNITION	**4**	**5**	**4**	**5**	**18**
• Estimate distance to other personnel.	2	1	0	1	4
• Locate your fire team members.	0	0	0	1	1
• Determine activity of your team or enemy.	1	0	0	0	1
• Identify specific fire team members.	0	0	0	1	1
• Identify assigned sectors.	0	1	0	1	2
• Identify dead space.	0	1	2	0	3
• Detect enemy soldiers.	1	2	2	1	6
WEAPON ENGAGEMENT	**2**	**5**	**1**	**7**	**15**
• Aim your weapon.	0	0	0	1	1
• Fire your weapon.	0	0	0	1	1
• Detect enemy fire.	2	5	1	3	11
• Fire from tactical positions.	0	0	0	2	2
TOTALS					
• **Total Instances of Unable to Perform Reported**	**7**	**13**	**5**	**15**	**40**
• **Number of Tasks Soldiers Were Unable to Perform**	**5**	**7**	**3**	**12**	**27**

Table G -38

Tasks Unable to be Performed by Soldiers Across VICs – MOUT

TASK	VIC				Total Responses
	A	B	C	F	
MOVEMENT	**0**	**3**	**6**	**0**	**9**
• Move around and inside of buildings	*0*	*0*	*3*	*0*	*4*
• Enter door, window, hole.	*0*	*1*	*3*	*0*	*5*
• Move tactically.	*0*	*2*	*0*	*0*	*0*
ORIENTATION	**0**	**0**	**4**	**0**	**4**
• Move through a building knowing which rooms are cleared.	*0*	*0*	*2*	*0*	*2*
• Determine where team members are around and inside of buildings.	*0*	*0*	*2*	*0*	*2*
• Determine own movement direction.	*0*	*0*	*0*	*0*	*0*
• Maintain position relative to other personnel.	*0*	*0*	*0*	*0*	*0*
VISUAL RECOGNITION	**3**	**2**	**2**	**2**	**9**
• Estimate distance to other personnel.	*0*	*0*	*0*	*1*	*1*
• Locate your fire team members.	*0*	*0*	*0*	*0*	*0*
• Determine activity of your team or enemy.	*0*	*0*	*1*	*0*	*1*
• Identify specific fire team members.	*0*	*0*	*0*	*0*	*0*
• Identify assigned sectors.	*1*	*1*	*0*	*1*	*3*
• Identify dead space.	*1*	*1*	*0*	*0*	*2*
• Detect enemy soldiers.	*1*	*0*	*1*	*0*	*2*
WEAPON ENGAGEMENT	**3**	**2**	**2**	**2**	**9**
• Aim your weapon.	0	0	1	0	1
• Fire your weapon.	0	0	0	1	1
• Detect enemy fire.	3	2	1	1	7
• Fire from tactical positions.	0	0	0	0	0
TOTALS					
• **Total Instances of Unable to Perform Reported**	**6**	**7**	**14**	**4**	**31**
• **Number of Tasks Soldiers Were Unable to Perform**	**4**	**5**	**8**	**4**	**21**

Table G-39

Tasks "Performed with Difficulty" by VIC – 29 Palms

TASK	VIC				Total Responses
	A	B	C	F	
MOVEMENT	**3**	**6**	**1**	**1**	**11**
• Move over open, flat terrain.	1	1	0	0	2
• Move over hills and cross compartments.	0	2	0	0	2
• Move tactically.	2	3	1	1	7
ORIENTATION	**7**	**8**	**2**	**3**	**20**
• Determine own movement direction.	2	3	0	0	5
• Maintain position relative to other personnel.	2	3	1	2	8
• Determine where team members are in open, flat terrain.	1	1	0	0	2
• Determine where team members are over hills and cross compartments.	2	1	1	1	5
VISUAL RECOGNITION	**15**	**18**	**17**	**14**	**64**
• Estimate distance to other personnel.	2	2	4	3	11
• Locate your fire team members.	1	2	0	0	3
• Determine activity of your team or enemy.	1	4	2	2	9
• Identify specific fire team members.	0	0	0	0	0
• Identify assigned sectors.	2	3	4	0	9
• Identify dead space.	3	3	3	5	14
• Detect enemy soldiers.	6	4	4	4	18
WEAPON ENGAGEMENT	**6**	**5**	**6**	**2**	**19**
• Aim your weapon.	3	1	1	0	5
• Fire your weapon.	0	0	0	0	0
• Detect enemy fire.	2	2	4	0	8
• Fire from tactical positions.	1	2	1	2	6
TOTALS					
• **Total Instances of Difficult to Perform Reported**	**31**	**37**	**26**	**20**	**114**
• **Number of Tasks Rated as Difficult to Perform**	**15**	**16**	**11**	**8**	**50**

Table G-40

Tasks "Performed with Difficulty" by VIC – MOUT

TASK	VIC				Total Responses
	A	B	C	F	
MOVEMENT	**4**	**3**	**3**	**0**	**10**
• Move around and inside of buildings	1	2	1	0	4
• Enter door, window, hole.	1	0	1	0	2
• Move tactically.	2	1	1	0	4
ORIENTATION	**5**	**3**	**5**	**1**	**14**
• Move through a building knowing which rooms are cleared.	3	0	2	1	6
• Determine where team members are around and inside of buildings.	1	1	3	0	5
• Determine own movement direction.	0	1	0	0	1
• Maintain position relative to other personnel.	1	1	0	0	2
VISUAL RECOGNITION	**8**	**4**	**7**	**3**	**22**
• Estimate distance to other personnel.	2	1	1	1	5
• Locate your fire team members.	1	0	0	0	1
• Determine activity of your team or enemy.	1	1	0	1	3
• Identify specific fire team members.	1	0	1	0	2
• Identify assigned sectors.	1	0	0	0	1
• Identify dead space.	0	0	2	1	3
• Detect enemy soldiers.	2	2	3	0	7
WEAPON ENGAGEMENT	**3**	**4**	**2**	**3**	**12**
• Aim your weapon.	2	2	1	0	5
• Fire your weapon.	0	0	0	1	1
• Detect enemy fire.	1	1	0	0	2
• Fire from tactical positions.	0	1	1	2	4
TOTALS					
• **Total Instances of Difficult to Perform Reported**	**20**	**14**	**17**	**7**	**58**
• **Number of Tasks Rated as Difficult to Perform**	**14**	**11**	**11**	**6**	**42**

APPENDIX H
Methods Used to Move and Positions Used to Fire by VIC and by Data Base

Table H-1

Methods Used to Move by VIC During the 29 Palms Scenarios

METHODS USED TO MOVE	VIC A		VIC B		VIC C		VIC F	
	n[a]	%	n[b]	%	n[c]	%	N[d]	%
Walk	4	40	4	33	6	43	3	33
Run	1	10	0	0	1	7	0	0
Walk and Run	3	30	1	8	1	7	1	11
Walk and Crawl	2	20	3	25	3	21	3	33
Walk, Run, and Crawl	0	0	4	33	3	21	2	22

Note. n = number of scenarios in which that specific method was observed.
[a]N = 10. [b]N = 12. [c]N = 14. [d]N = 9.

Table H-2

Methods Used to Move by VIC During the MOUT Scenarios

METHODS USED TO MOVE	VIC A		VIC B		VIC C		VIC F	
	N[a]	%	n[b]	%	n[c]	%	n[d]	%
Walk	11	85	11	58	10	83	6	38
Run	0	0	0	0	0	0	3	19
Walk and Run	2	15	6	32	0	0	7	44
Walk and Crawl	0	0	1	5	1	8	0	0
Walk, Run, and Crawl	0	0	1	5	1	8	0	0

Note. n = number of scenarios in which that specific method was observed.
[a]N = 13. [b]N = 19. [c]N = 12. [d]N = 16.

Table H-3
Positions Used to Fire by VIC During the 29 Palms Scenarios

POSITIONS USED TO FIRE	VIC A		VIC B		VIC C		VIC F	
	n[a]	%	n[b]	%	n[c]	%	n[d]	%
Standing Unsupported	2	40	0	0	0	0	1	20
Kneeling	2	40	0	0	0	0	2	40
Prone	0	0	6	100	6	100	1	20
Standing and Kneeling	0	0	0	0	0	0	1	20
Kneeling and Prone	1	20	0	0	0	0	0	0

Note. n = number of scenarios in which that specific position was observed.
[a]N = 5. [b]N = 6. [c]N = 6. [d]N = 6.

Table H-4

Positions Used to Fire by VIC During the MOUT Scenarios

POSITIONS USED TO FIRE	VIC A		VIC B		VIC C		VIC F	
	n[a]	%	n[b]	%	n[c]	%	n[d]	%
Standing Unsupported	3	100	10	77	0	0	9	100
Kneeling	0	0	0	0	1	33	0	0
Prone	0	0	2	15	2	67	0	0
Standing and Prone	0	0	1	8	0	0	0	0

Note. n = number of scenarios in which that specific position was observed.
[a]N = 3. [b]N = 13. [c]N = 3. [d]N = 9.

APPENDIX I
Interview Results

Interview Results

Responses from the soldier interviews were first organized by question and by VIC and are presented in Appendix H. The responses were further refined and the key points extracted. These points were organized by area (move, shoot, communicate, maintain situational awareness, realism, and miscellaneous) and by VIC and are presented in Tables 15–18. The major points are summarized briefly in the following sections.

Results from the soldier interviews conducted after the exercises were summarized and are broken down by question. Key points are presented in the following sections.

What Were the Best Features of Each VIC?

Features or aspects were organized around six major areas for most questions: move, shoot, communicate, maintain situational awareness, realism, and miscellaneous/data base specific issues.

VIC A

Move. Soldiers reported that movement in this VIC was realistic and found it easy to move upstairs in buildings.

Shoot. Soldiers indicated that target engagement was like the real-world and involved using a real weapon. VIC A's system makes the individual scan his sector. The heads-up display did not get in the way. Soldiers actually got to hold the rifle up and aim.

Communicate. No responses.

Maintain situational awareness. Recognition of objects and people to include the OPFOR was very clear. Soldiers could easily distinguish fire team members from the enemy. They could look around corners (if they leaned forward). Quick reaction is possible. Soldiers indicated that when you see the enemy in the circle, you get a corresponding real-time movement of the visuals.

Realism. The virtual aspect of the headset provided a realistic sensation. You could see your hands. The view bounces as you walk, like truly being untethered.

Soldiers felt like they were really training because you had something on your head. (display). They also liked the idea of carrying your LBE.

Miscellaneous and data base specific. Can go by the floor compass (north, south, east, and west arrows taped on the floor) although this was not too accurate. The soldiers felt that the system put you in another world (due to its immersion-like qualities).

VIC B

Move. Soldiers indicated that in VIC B you actually move. You could use your legs to move, turn, and maneuver. They felt that it simulated movements the best. Soldiers felt that movement on VIC B was closest to real-world movement. Appropriate resistance was applied to different terrains, e.g., walking on level ground or walking up hills. They also indicated that you could also move sideways and side step around corners. In MOUT you can look and see where you are going.

Shoot. Soldiers indicated that you could see where the rounds were going in MOUT. You can see rounds hit sometimes. The reticle lights up (black) when you are on target so you know you are on it. Soldiers liked being able to manipulate their weapon the way you are supposed to. The weapon was accurate. The capabilities of the weapon system were well received. Recognition of objects and people were clear. Could easily distinguish fire team members from the enemy. Soldiers also liked that you could see around corners, which was excellent for MOUT. They liked the concept of being able to fire around corners.

Soldiers indicated that you could aim with ease and hit targets. Aiming was correct. IHAS and the pictures were enhanced. The eyepiece (IHAS) was good. You could see side-to-side.

Communicate. No responses.

Maintain situational awareness. Soldiers indicated that having four screens made situational awareness easy; you have a 360 degree view; you see all three sides at once; you see everything; the field of view is larger. You could look over your shoulder as you would in the real world. If your team leader gives a directive you can look over and see him out of the corner of your eye. Soldiers felt that that it was easier to know where teammates were and to recognize them; you don't have to turn the whole body to see others. They liked the indirect visual capability of the weapon which allowed them to look around corners.

Realism. Soldiers felt that VIC B was the most realistic; it allowed you to perform tasks with the fewest differences from tactical procedures. You could get into the exercise/action, e.g., can hump up a mountain. Realism was provided by the factors noted earlier: treadmill, accurate aim of the weapon, and the screen set-up. The system also allowed you to estimate distance and determine dead space.

Miscellaneous and data base specific. For some soldiers, the more familiar they became with the system, the more they liked it. They also noted the reliability of the system. It approximated real training in that you had something on your back and the realistic aspect of walking over different terrains was wearing for some soldiers. The ability to peek around the corners was better in the MOUT environment but not as useful in the desert.

One soldier was observed to use the video camera (the eyepiece) with his non-dominant and left eye when the enemy was close. He used his right and dominant eye in moving formation because he wanted a wide field of vision.

VIC C

Move. Movement was easy, because it was like a video game. All you had to do was turn the joystick or push a switch.

Shoot. Soldiers indicated that the visuals were clear which made it easier to identify personnel. It was easy to shoot; just point at a little dot and shoot. Viewing and scanning were easy using the joystick. Soldiers had no problem aiming. There was no bouncing around, just fire. Aiming and shooting were very accurate. Targets could be engaged quickly. The SAW reticle weapon system was liked, along with the capability to select from a variety weapons.

Communicate. Soldiers liked having the microphone right in front of them and the quietness of the system.

Maintain situational awareness. Soldiers knew if they were prone or not because their perspective of the VE changed accordingly. They could see the OPFOR in the desert. They could also tell how fast they were going and in which direction.

Realism. Soldiers could easily tell when they were prone. They could also go from kneeling to prone, and standing positions quickly.

Miscellaneous and data base specific. Soldiers liked having a map and a compass. Some felt that the compass was the only good thing; you could know where you were at with the compass. Binoculars were also seen as a positive feature of the system.

VIC F

Move. Movement was easy. Movement was quick; you could maneuver and move faster; you could go backwards. By moving your head you could change direction and then use the foot petal to move. Could move better as part of a fire team and as an individual. Soldiers indicated that you could go up to, but not through the wall. When you hit the corner you don't immediately go around it in a flash, you have to "pie" it

(going in little pieces like cutting a pie). Soldiers also liked the fact that you could see where you were going in MOUT.

Shoot. The system was good for engaging targets because you were using an actual weapon. You could also see where the rounds were going in MOUT. You have to manipulate your weapon the way you are supposed to; the weapon system (how you hold it) is tactically sound. Soldiers also liked the fact that you had to actually aim the weapon and that tracers were used. The system allowed you to look around corners in MOUT. You could identify the enemy better.

Communicate. No responses.

Maintain situation awareness. Soldiers liked that you could turn your head back and forth and around quickly; other systems required that you use your whole body. The big screen allowed you to see very well. Leaning toward the screen to look in a room was a positive feature. The system also allowed you to look around corners by turning your body and head. Peripheral vision was good; you could tell positioning of fire team members easily. You could see where the rounds were going.

Realism. The size of things was very realistic. Soldiers indicated that it felt like you were actually moving in the scene. The system requires real world movement in terms of going prone or taking a knee.

What Were the Least Desirable Features of Each VIC?

VIC A

Move. Easy to move too far from the circle and out of the box, resulting in need to recalibrate. Circle and box were too small. If you move out and your team leader wants you to come back or move a certain way, you can't step backwards, so you have to turn around to go backwards.

Speed was hard to maintain; you can't change your speed or feel how fast you're going. It is hard to slow down; no way to slow down normally; no way to keep pace slow. It was so unnatural to move with the system, that VIC A was always the last to enter buildings. You had to constantly look down to see if you were in the circle (the only area where the soldier could move or have the sensation of moving through the virtual headset).

You would lose direction if you looked around you. When you start to walk and try to slow down you have to stop and start over. You can't go backwards and you can't back up. You can also fall through windows.

Shoot. You can't switch hands or you have to be recalibrated. The weapon sight did not duplicate the M16. Sometimes the weapon was canted. Problems with firing

when moving were noted. The weapon was jittery. The weapon would jump. You would be pointing the weapon straight, but it would be going to the left or right of you. You would have a person right in front of you and your weapon would jump. The way the weapon and everything works makes it difficult to recognize targets. You had to look at the image of the weapon, not at the weapon. Could not hit anything with the weapon. Sometimes you would aim your weapon and it would point backwards or behind you. The headpiece and aiming is not right. You had to wait on the computer to set aim and allow the screen to stabilize (settle down, stop moving).

Communicate. You can't hear anything. You can't speak because you have to hold your hand up to the microphone.

Maintain situational awareness. The screen gets blurry when you see people or objects, especially in the distance you can't distinguish friend from enemy and you have to recalibrate. Problems with the visuals were noted. It feels like you are wearing blinders. You have to scan around to find people and that is sometimes hard. All you can see is 45 degrees at one time. Depth perception and peripheral vision are bad; soldiers did not like non-peripheral/tunnel vision characteristics.

Realism. Need to be able to do weak hand shooting like law enforcement does (to go around corners). Tactically, soldiers felt that this was the worst system. For example, assuming a tactical position (knee) sometimes worked, other times, it did not. Things happen like walking through walls that don't happen in real life. If you hit a wall, you don't stop, you go through it. Can't get into prone position because of the sensors, only kneeling. Soldiers indicated that it is hard to get in prone position without messing up the sensors. You can do anything in the box (but small area is problematical).

Miscellaneous and data base specific. The screen jumped in 29 Palms. When it got blurry, contractor/technician adjusted the distance of the headset from the soldier's eyes. The system broke down a lot and needed recalibration. You have to start over too much. The little sensors sticking out fall off.

VIC B

Move. The treadmill. You go on it and stop and it is still moving. In walking up a hill and then stopping, your hips are likely to move and the ODT throws your body left and right. Too slow. Hard to walk in a straight line. Actual movement was unstable. Difficult to move as team. It was hard to keep up with the rest of the fire team. Being strapped in restricted movement. Couldn't stop quickly. Hard to stop when you are trying to go around corners. It (treadmill) keeps going. As a result you're exposed and get shot. Should stop and then turn, but movement is hard. If you turn to look behind you and turn your body, the treadmill moves. Walking makes your legs rubbery. You feel your feet slipping out from under you. Directional movement was difficult because the VIC pulls against you. The treadmill speeds up and slows down without warning and not when you want it. It rocks back and forth. When walking forward, you can't

automatically turn to the left or right as you would normally. If you move off-center the machine jerks you around. Should be able to turn while walking.

Shoot. Peeking around corners. You can't do that in real life. This takes away from training. The visuals were blurry. Weapon needs to be correct weight. One eye on screen and one in the IHAS is difficult. Difficult to determine dead space. Weapon needs to be aligned with IHAS in peeking around corners.

Communicate. Noise of VIC B made commo difficult. You could not hear.

Maintain situational awareness. No comments.

Realism. Sensor system would intermittently jerk or pull the soldier back (through the tether attachment) in MOUT setting where there were no hills. Tethering was a problem. It produced jerky movement. Belt and harness are restrictive and unnatural. No freedom in movement. The buttons to kneel or go prone are not very realistic. Weapon deployment unrealistic. Did not use indirect fire mode. Shouldered weapon to fire.

Miscellaneous and data base specific. The oil stinks. Change the sensors on the hip. They are too sensitive to hip movement. It is difficult to maintain balance. Rollers sometime get out of control.

VIC C

Move. One soldier indicated that it was hard to move because he was left handed and felt handicapped (due to the positioning of the controls). Movement of the joystick was seen by some as being too sensitive.

Shoot. It was hard to see things on the screen; people were so far away that you could not tell if they were friend or enemy. Had to expose yourself to the enemy to fire. Soldiers had no weapon, only the reticle on the screen. It took longer to aim than in real life because you had to move the joystick. Aiming was unrealistic. Soldiers preferred to be standing and actually holding a real weapon.

Communicate. No responses.

Maintain situational awareness. You can move both head and body independently with the joystick, but you forget where you are, then you have to hit reset to get your head back in position and aligned with your body. One soldier thought that he was close to the wall, but on the master computer screen he was five feet from the wall, exposing himself to the enemy. He could not tell distance from the walls. Must fix the lack peripheral vision.

Realism. You are sitting down, controlling a joystick. This is not very realistic. It's like playing a video game. It was more like a video game than virtual reality. It

needs to be more realistic. It seems fake. You don't feel like you are really in there participating with the team. The system is also not realistic with regard to marksmanship, since you are not holding the weapon.

Miscellaneous and data base specific. System must allow the individual to go into buildings. Current system does not allow you to enter buildings. Soldiers assigned to this system pulled guard outside in the MOUT scenarios. One soldier noted that the system was not made for left handed people. In Orlando he had a different joystick and it was not a problem.

VIC F

Move. Some trouble was reported while moving on "autopilot" and it was difficult to control the speed. Crawling was difficult; have to put your elbow or something on the pedal to make it go in that position. Hard to move in building. Soldiers reported bumping into walls.

Shoot. Consistently hit lower than your aim point. If you fired at the sky, you would hit the upper body. If you fired at the waist, you would hit the floor. People sometimes killed themselves when aiming because the weapon was not aimed/calibrated correctly. Soldiers could not hit anything. The weapon was not accurate. The contractors tried to correct the aim of the weapon during the training and the exercise. At the end (of the exercise), the aim was off to the right. In the prone position, you must push the pedal with your hand. That takes one hand off the weapon and you can not fire quickly. Can not play weapons other than the M16.

Communicate. No responses.

Maintain situational awareness. Soldiers never saw the enemy in the desert. They kept getting stuck and therefore did not see much of the enemy.

Realism. Tactical positions were problematical. For example, when you got prone, you would slide down the hill. Movement was unrealistic.

Miscellaneous and data base specific. Need two more screens. In the present system, you have to turn your head to look left and right. The cords got in the way. The wire that held the rifle and head harness got in the way. This needs to be fixed. Sometimes when you turn your head to one side it turns the screen too slow. Turning to one side is faster than the other.

In Which VIC was the Visual Display Most Like the Real World?

VIC B. (Five soldiers selected VIC B). You have a full 360 degree view (or at least 260) and things are usually there when you look for them/at them, unlike the other systems, which, when you turn your head and then turn back, things disappear and you have to wait for them to reappear. It was fun.

Your legs and arms are moving. You have to do something to make it go. You can control your own speed.

It is the most realistic in that everywhere you look you see the terrain. You can look around corners. You get worn out (using the treadmill) so you actually walk slower, as in real life. It is not like pressing a button to move. It simulates fatigue.

One soldier described his preference in terms of an interaction between what a soldier sees and what he must do. When you see a depression to your front, you must adjust your movement accordingly. Good interaction between visual cues in VIC B and body movements. The soldier indicated that he experienced the visual cues first.

You could see more. You could look left and right. Had to turn all the way round to look behind you, however, and it took sometime to learn how to use the weapon sight. Where other systems provided just a straight ahead view, VIC B provided more of a 360 degree view.

Other Comments

VIC C. In 29 Palms you could follow the terrain, the color shades were easy to follow. It would be Foxtrot for MOUT, though. Actually it is easier to use the terrain in VIC C because of the map.

VIC B and VIC F. These systems were about the same. These VICs provided the most realistic display. The VIC A screen moved too much when turning.

VIC F. Large screen. View changed by moving the head. The size of the buildings and soldiers looked real.

In Which VIC was the Visual Display Least Like the Real World?

VIC C. (Seven soldiers selected Charlie). Limited visual angle. Distance estimation was bad. You are just looking at the screen and that's it. Charlie was easier to aim, but it was less realistic.

One soldier made his judgment based on the interaction between visual cues and body movements. In VIC C, you can not tell, visually, how fast you are moving, specifically in the desert. (The computer scale was an indicator, but it was not helpful to

him.) It was easy for him to get ahead of others in the fire team without knowing it in the desert. Couldn't see ground depressions on VIC C as well as in VIC B. He also indicated that you could not see depressions in VIC F.

This system was seen as the least virtual of the VICs. One soldier indicated that it was like playing a video game. He could sense and see other people around him which was probably distracting.

You just sit down and you don't hold a weapon and you can't go into buildings.

Playing with the joystick, moving toward people with your hands is not realistic. (Toggling with joystick does not simulate actual behavior or effort needed to move in reality.)

It is unrealistic because you can't do anything inside a building. You can't even see anything in the buildings. It makes you useless (to your team) in a MOUT site.

VIC A. The color was OK but you could not see things if they were far out. But things were also hard to see if they were somewhat close.

What Things Need to be Changed in the Desert Environment?

Realism of the Terrain

Needs to be more realistic, not just plain dirt. Add vegetation, bushes, tumbleweeds, boulders, rocks, cactus, trenches, obstacles, trees, etc.

Graphics

Graphics need to be more realistic; more like the DISAF with hill crests instead of the razor peaks. The hills need to be more rounded. The terrain is too square with lines all over it. The sharp angles of hills are unrealistic; need more curves. The pyramid mountains have to go. Pointed sand dunes are not real. Sometimes the shape of the dunes tricks you into thinking that you have cover when you are actually in the open, exposed. What you see on the screen doesn't reflect what you see on the computer screens of the AAR. You don't see ravines, etc. on your system (VIC) but you do on the master computer.

Cover and Concealment

There is nothing to get behind, e.g., hill crests. Need to put in some cover. The cover would allow you to practice individual movement techniques. There was no concealment in this environment on any of the VICs. No cover unless you are in a dead space.

No distance estimation. The hills in the distance don't look that big but when you climb up them, it takes forever. No depth perception. Must improve ability to detect dead space. It all looks the same. Color shading might help as it does in the real world.

Enemy

There was no indication of the OPFOR position, e.g., bunker, although with a small OPFOR element there might not be a bunker. But there also were no tracks of vehicles in the sand; and no other indications that the enemy might be present, or if present, how it got there. The enemy was too well camouflaged. They could be only a 100 yards away and you could not see them. That would not happen in the real world even if they were wearing desert camouflage.

Navigation

Improve distinctiveness of terrain when viewed from a distance. One hill top looks like the objective and then it isn't. You get misoriented. There's no compass, no degrees. Two miles is like 200 meters.

Exercise Specific

With 29 Palms you have the same start point each time, just go left or right. Change the missions. They always put the enemy on top of a hill and you at the bottom and you have to walk way around to get to your objective.

What Needs to be Changed in the MOUT Environment?

Walls

When you hit a wall you should stop or make a bumping noise. On some systems (VICs) the walls look paper-thin. They should look like a real wall, solid so that you can't see through them. Sometimes you jump up or go through walls. You can also get shot through walls. In some VICs, if you walk through a wall it puts you on the first floor. Make the walls solid. Improve graphics.

Buildings

You should be able to go into all buildings. Some buildings should be made different shapes so that you don't get so confused. Make them more distinct. Put doors inside rooms. Inside buildings, you need color and texture changes to differentiate rooms. Charlie can't see in the buildings. Add furniture and fixtures inside buildings. You don't know where you are inside the building. All the walls, floors, and ceilings are gray. There are no distinguishing characteristics to the rooms. It is hard to tell the size of the rooms.

See

Soldiers indicated that it was important that everybody should be able to see the same thing (soldiers in VICs and between VICs and MOD SAF), i.e., "fair fight".

Environment

Need more things to maneuver around, e.g., cars, tanks, more trees and other things outside; sewer systems to go through; obstacles, booby traps, wire obstacles. There needs to be rubble, and high weeds for concealment.

Civilians

Need to play civilians so you can train soldiers to distinguish them from the other OPFOR and not shoot indiscriminately.

Weapons

Should be able to use grenades and other dismounted infantry equipment.

Scenario

The OPFOR would not be in the open, they would be inside. If you are near a building and can get inside for it to protect you, you would do it that way, not this way.

How Would You Build a New and Better VIC Using Features from the Existing VICs?

Move

VIC A. Incorporate movement of VIC A where you could see that you were moving and your movements show up. Include head movement, mobility, and quick reaction characteristics of VIC A.

VIC B. Incorporate real-time movement plus the forces on your body which produces actual fatigue. Improve the treadmill. Make it quieter without the harness. The treadmill needs to stop when you stop and not try to re-center you.

VIC F. Include the speed of Foxtrot and incorporate VIC F's kneel and prone methods.

Shoot

VIC A. Include screen mounted on face/headset with peripheral vision.

VIC B. Incorporate indirect fire and seeing capability, but no IHAS. IHAS gets in the way, very annoying. Include rifle with eyepiece camera mounted on the weapon.

VIC C. Incorporate feature which allows the soldier to select weapon options, reticle, and use of binoculars.

VIC F. Weapon must have the weight, feel, and balance of a real weapon. No eyepiece, use actual weapon sight. Should be able to see where the rounds are landing.

Communicate

VIC F. Incorporate VIC F headpiece. You just need the ears.

Maintain Situational Awareness

VIC A. Include Alpha's scanning technique.

VIC B. Include Bravo's ability to look around corners with the camera. Allow the individual to be able to keep aware of others by turning around and looking as you would in the real-world.

VIC C. Include map and compass. Provide option to be able to change view up and down.

VIC F. Include Foxtrot's movement and visuals capabilities.

Miscellaneous

Keep VIC A's LBE.

What New Feature or Capability Would You Add to Improve Individual Performance?

Move
- If you hit a wall, you should stop.

Shoot
- Add magazines for ammo and simulate the time you would actually take to reload.
- Need those laser aiming things.
- Grenades.
- If you have the SAW, then you should be using the SAW in the simulator. (Similarly, if you are the grenadier, then you should be using the specific weapon on the simulator and not an M16)

Communicate
- Smoke.
- Flares and other signals.
- Hand and arm signals.
- Better commo. Turn it up. Use better speakers. Put a muffler on Bravo (so soldiers can hear better).

Maintain Situational Awareness
- Add night vision goggles.
- Night sights.
- Binoculars and scopes.
- Large screens like VIC F, plus additional screens for above, below, and behind.
- Real map and compass.
- Better direction of fire. Soldiers never knew what direction the firing was coming from in any VIC. Have uni-directional speakers so that if they are shooting at you from the left you hear it from the left.

Miscellaneous
- Night scenario capability.
- More realistic weight load (LCE and body armor/Kevlar)

What New Feature or Capability Would You Add to Improve Team Performance?

Move
- Try to make all VICs the same speed.

Shoot
- Sniper feature.
- Grenades.

Communicate
- Smoke.
- Flares.
- For commo you need throat mikes so it is not in the way and/or something like what the AT&T operators use.
- Radio. No communication between team members and the team leader (this probably would lead to bad habits and negative transfer among team members if they got too dependent or use to this type of intra-team member radio communication.
- Should be radio communication between the squad leader and the team leader.
- Commo should only be heard by those parties talking to each other (the other soldiers thought that allowing everyone to listen was a bad idea).
- Hand and arm signals. Putting sensors on the soldiers' hands to be able to play arm and hand signals among soldiers in the VICs.

Maintain Situational Awareness

- Add binocular capability.
- Have screens but have three so you wouldn't have to turn so far, and maybe even have one on the top so when you look up you can see overhead.
- In MOUT you might have booby traps high up on the ceiling. You need to be able to find them. The screen would go up so you could see up.
- Direction of fire. Hard for some soldiers to tell where the enemy was firing from.

Miscellaneous

- Enhance the visuals.
- Differentiate appearance of team members without tagging them. The enemy looks different in each VIC (in some they (the uniforms) are green, in some they are gray).
- Make the uniforms the same.
- Limited visibility capability.
- Design way to make cover and body armor work, i.e., to actually give protection.
- In MOUT there should be some way to mark rooms that are cleared.